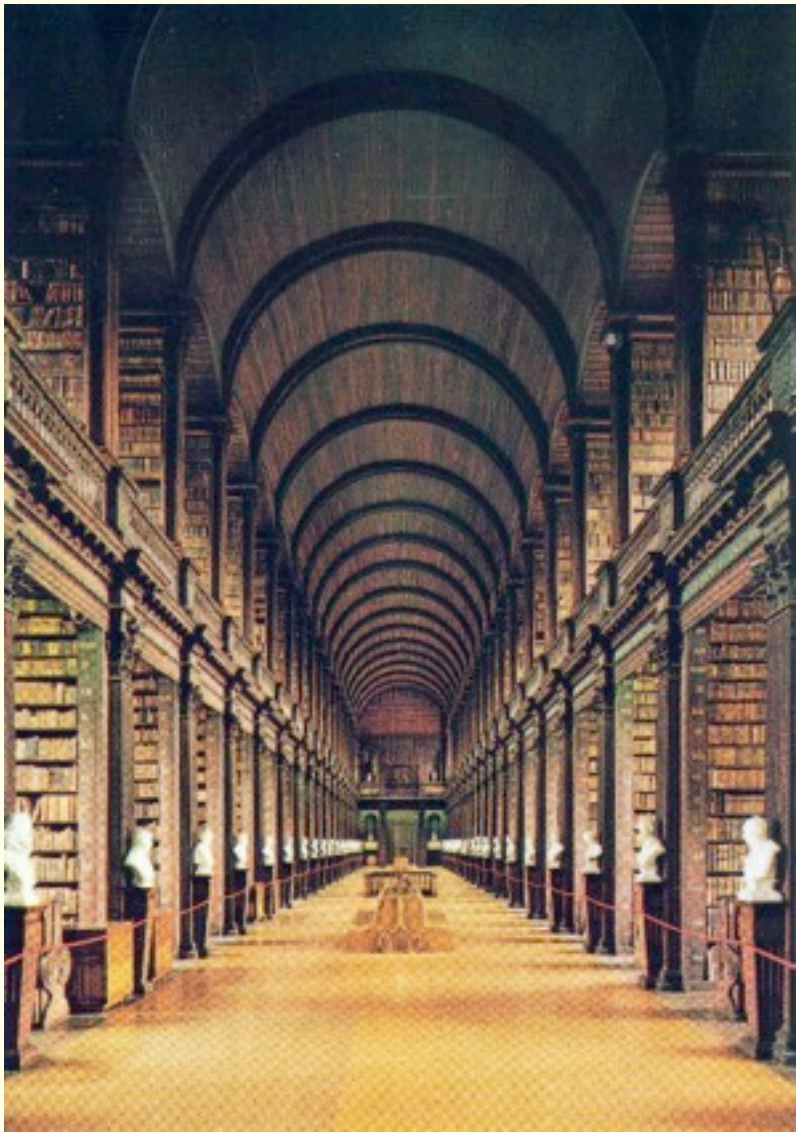
From Copernicus to Newton

For many centuries books were precious and expensive

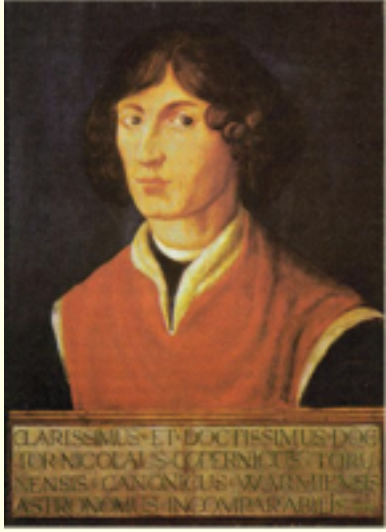
The university library in Paris had only 1017 books In 1289

Johann Gutenberg from Mainz perfected printing from movable metallic cast and in 1455 printed the first Bible

Until the end
of the XVth century some
35-40 thousand books
were printed in
the total number
of about 10 million copies!



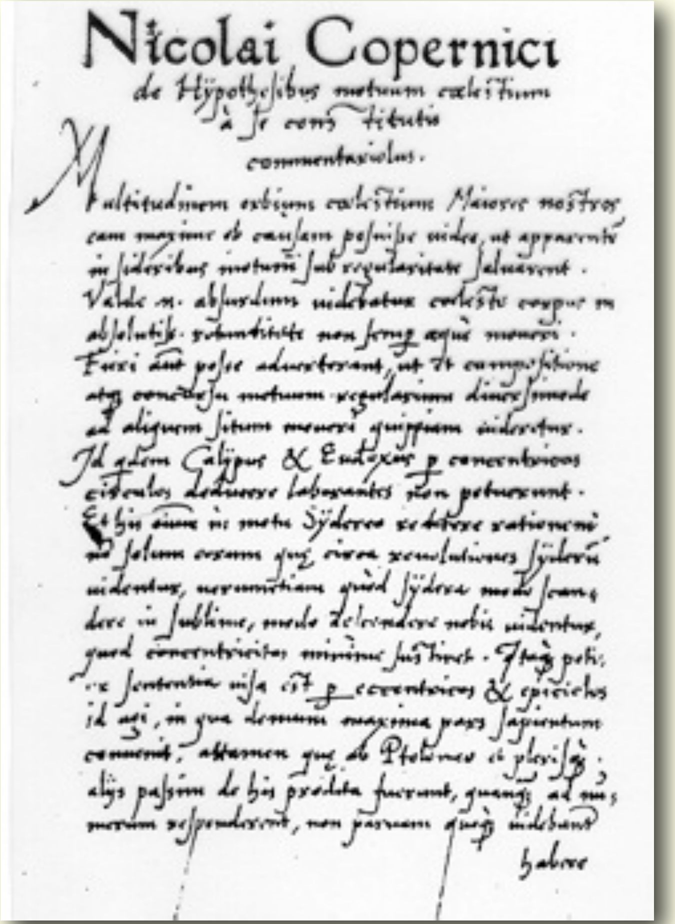
Nicolaus Copernicus



19 II 1473	Born in Thorn (Toruń)
1491-1495	Studied in Cracow
1496-1501	Studied in Bolonia, visit to Rome
1501-1503	Studied in Padua, doctorate in Ferrara
after 1503	in church administration in Ermland (Warmia) - mainly in Frauenberg (Frombork)
before 1514	*Commentariolus*
1526-1528	*Monetae cunendae ratio*
1540	*Narratio prima* by Rheticus
1542	*De lateribus et angulis triangulorum*
1543	*De revolutionibus orbium coelestium*
24 V 1543	Died in Frauenberg (Frombork)

”...by St. Anne’s church there is a university renowned for its many distinguished and learned scholars, who teach the liberal arts, rhetoric, poetics, philosophy, and physics. Astronomy is the most highly developed science. In the whole of Germany (and I know it from more than one source) one can not find a more famous school.”

Hartman Schedelius, *Opus de historiis aetatum mundi* [*Chronicle of the World* (1493)]


Nicolai Copernici
de Hypothesibus motuum coelestium
a se constitutis
commentariolus.

Multitudinem orbium coelestium Maiores nostros
eam maxime ob causam posuisse video, ut apparentem
in sideribus motum sub regularitate salvarent.
Valde n. absurdum videbatur coeleste corpus in
absolutiss. rotunditate non semper aeque moveri.

Commentariolus by Copernicus

Earliest evidence
from 1514

Postulates:

1. There is no one centre of all the celestial spheres
2. The centre of the earth is not the centre of the universe
3. All spheres surround the sun and therefore the centre of the universe is near the sun
4. The distance between the sun and the earth is imperceptible compared with the great height of the sphere of the fixed stars
5. Whatever motion appears in the sphere of the fixed stars belongs not to it but to the earth
6. Whatever motions appear to us to belong to the sun are not due to the sun but to the motion of the earth
7. The retrograde and direct motion that appears in the planets belongs not to them but to the motion of the earth. Thus the motion of the earth by itself accounts for a considerable number of apparently irregular motions in the heavens

”And so altogether, Mercury moves on seven circles, Venus on five, the earth on three and the moon about it on four, and finally Mars, Jupiter and Saturn on five each. Therefore, taken as a whole, 34 circles are sufficient to represent the entire structure of the heavens and the entire choric dance of the planets."

Commentariolus

De revolutionibus *orbium coelestium*

Book I	Introduction and plane and spherical trigonometry
Book II	Catalogue of fixed stars
Book III	Theory of precession
Books III-VI	Orbits of the earth, moon and planets

NICOLAI CO-PERNICI TORINENSIS

DE REVOLVTIONIBVS ORBIUM cœlestium, Libri VI.

Habes in hoc opere iam recens nato, & ædito, studiose lector, Motus stellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obseruationibus restitutos: & nouis insuper ac admirabilibus hypothesibus ornatos. Habes etiam Tabulas expeditissimas, ex quibus eosdem ad quoduis tempus quàm facillime calculare poteris. Igitur eme, lege, fruere.

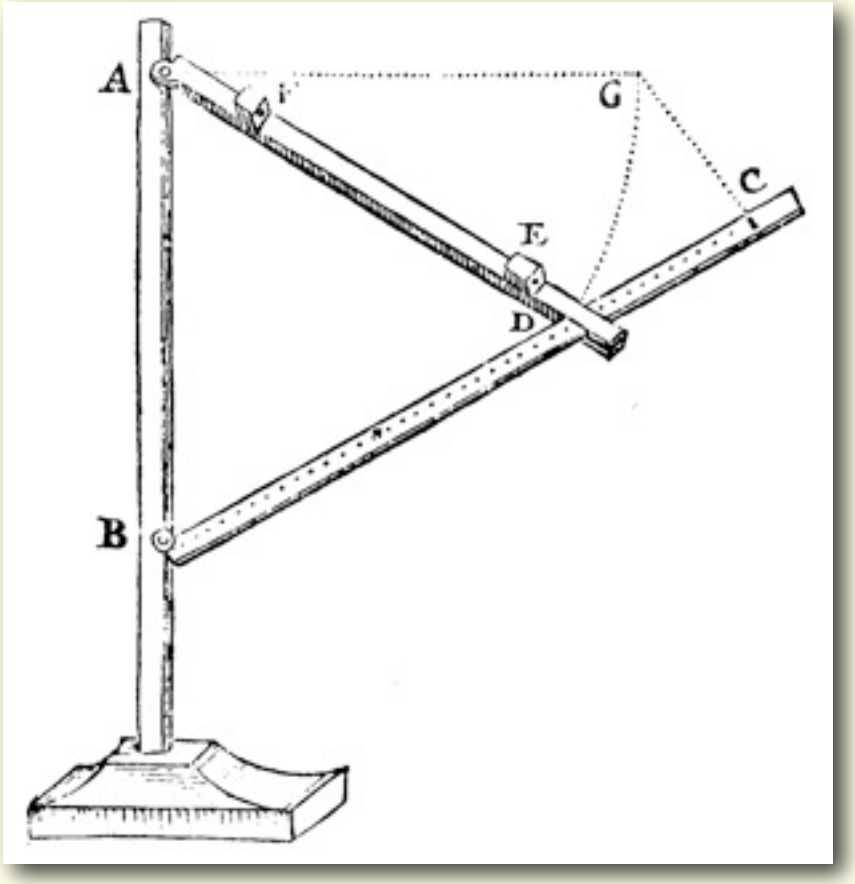
Ἀγεωμέτρητος οὐδεὶς εἰσίτω.

Norimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

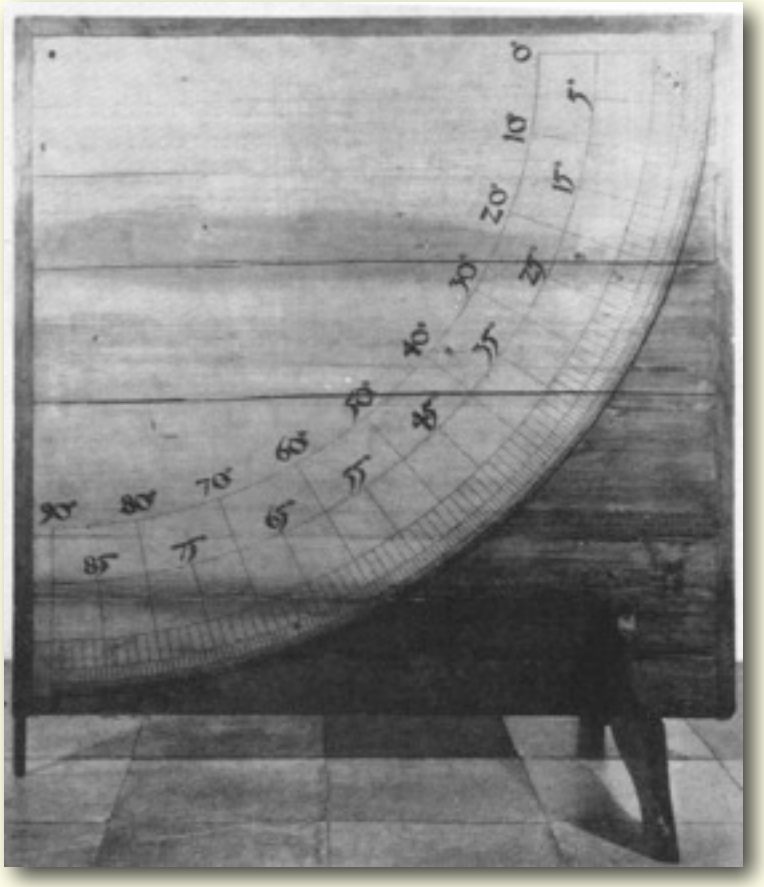
net, in quo terram cum orbe lunari tanquam epicyclo contineri diximus. Quinto loco Venus nono mense reducitur. Sextum denique locum Mercurius tenet, octuaginta dierum spacio circũ currens. In medio uero omnium residet Sol. Quis enim in hoc

pulcherimo templo lampadem hanc in alio uel meliori loco poneret, quàm unde totum simul possit illuminare? Siquidem non inepte quidam lucernam mundi, alij mentem, alij rectorem uocant. Trimegistus uisibilem Deum, Sophoclis Electra intuentẽ omnia. Ita profecto tanquam in solio regali Sol residens circum agentem gubernat Astrorum familiam. Tellus quoque minime fraudatur lunari ministerio, sed ut Aristoteles de animalibus ait, maximã Luna cũ terra cognationẽ habet. Concipit interea à Sole terra, & impregnatur annuo partu. Inuenimus igitur sub hac

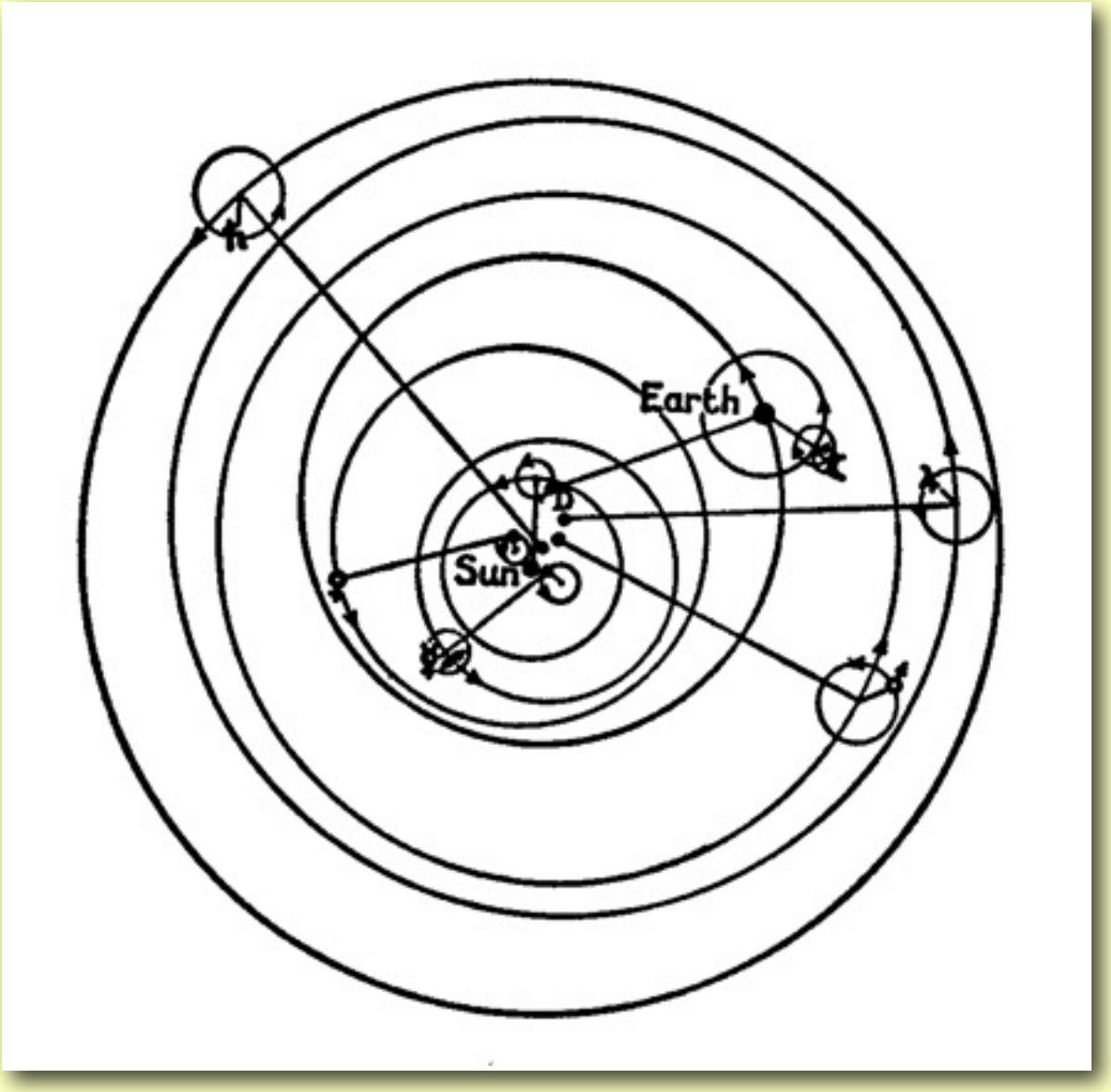
Instruments of Copernicus



Triquetrum
De revolutionibus
(Edition of 1617)



Quadrant (reconstruction)



Copernican system was **heliostatic**, not heliocentric

”Chapter I. That the universe is spherical

First we must remark that **the universe is globe-shaped**, either because that is the most perfect shape of all, needing no joint, an integral whole; or because that is the most capacious of shapes, which is most fitting because it is to contain and preserve all things; or because the most finished parts of the universe, I mean the Sun, Moon and stars, are observed to have that shape, or because everything tends to take on this shape, which is evident, in drops of water and other liquid bodies, when they take on their natural shape. There should therefore be no doubt that this shape is assigned to the heavenly bodies.”

Copernicus, *De revolutionibus*, Book I

”Chapter IV. That the motion of the heavenly bodies is uniform, circular, and perpetual, or compounded of circular motions

The next point is that **the motion of the heavenly bodies is circular**. For the movement of a sphere is a revolution in a circle, expressing its shape by the very action, in the simplest of figures, where neither beginning nor end is to be found, nor can the one be distinguished from the other, as it moves always in the same place. Yet a number of motions are possible for a multiplicity of spheres.”

Copernicus, *De revolutionibus*, Book I

”The most obvious of all is the daily revolution, which the Greeks call *νυχθήμερον*, that is, the duration of a day and a night. By this motion the whole universe is thought to glide from east to west, except the Earth. This is accepted as the common measure of all motions, since we generally measure time itself by the number of days. Then we see other revolutions tending as it were in the opposite direction, that is from west to east, I mean those of the Sun, Moon and five wandering stars. Thus the Sun marks out the year for us, and the Moon the months, which are very common units of time; and the other five planets each make their own circuit.”

Copernicus, *De revolutionibus*, Book I

”But they have differences in their various motions. First, they do not revolve on the same axes, but round the zodiac which is set at an angle. Secondly, they do not seem to move uniformly in their own orbits, for the sun and moon are observed to be sometimes slow and sometimes quicker in their movement; whereas we notice that the other five wandering stars sometimes even retrace their steps and come to a halt on each side. And though the Sun always travels strictly along its own path, the others wander in various ways, diverging now to the south and now to the north, which is why they are called planets. Furthermore they are sometimes nearer to the Earth, and are said to be in perigee, and sometimes further from it, when they are said to be in apogee.”

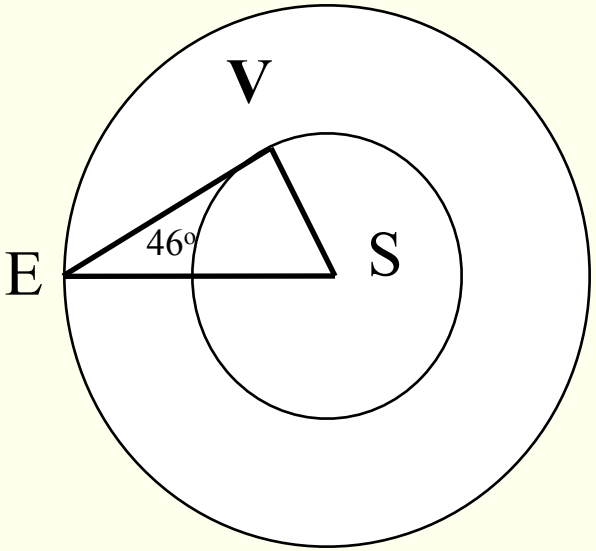
Copernicus, *De revolutionibus*, Book I

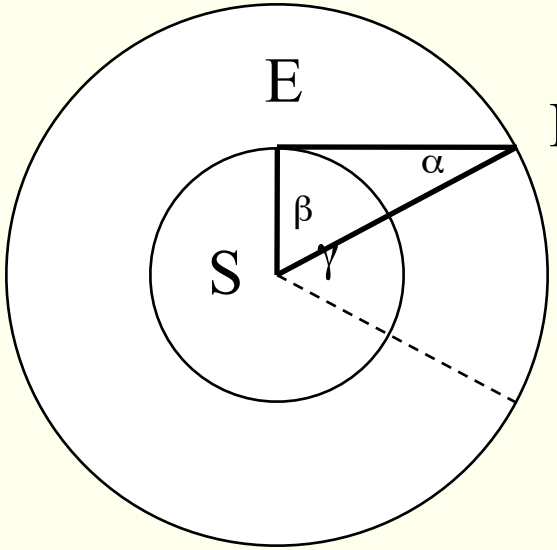
”Nevertheless it must be admitted that their motions are circular, or compounded of a number of circles, because they pass through irregularities of this kind in accordance with a definite law and with fixed returns to their original positions, which could not happen if they were not circular. For only a circle can repeat a previous state of affairs, for example in the following way: it is by a motion compounded of circles that the Sun repeats for us the cycle of lengthening and shortening of the nights and days, and the four seasons of the year. In this several motions are detectable, since **it is impossible for a heavenly body which is simple to move irregularly in a single sphere.**”

Copernicus, *De revolutionibus*, Book I

”That would have to be due either to changes in the moving power, whether derived from elsewhere or from its intrinsic nature, or on account of unevenness in the revolving body. Both **these possibilities are unacceptable to the reason**, and it is inappropriate to attribute such a thing to bodies which are established in an ideal state. It must therefore be agreed that though their motions appear to us irregular they are regular, either because the axes of their circles are different, or perhaps because the Earth is not in the middle of the circles in which they revolve, and to us observing from the Earth the transits of these stars it comes about that because of the different distances they seem larger when they are nearer than when they are further away.”

Copernicus, *De revolutionibus*, Book I





Quadrature

Opposition

$$VS/ES = \sin 46^o = 0{,}72$$

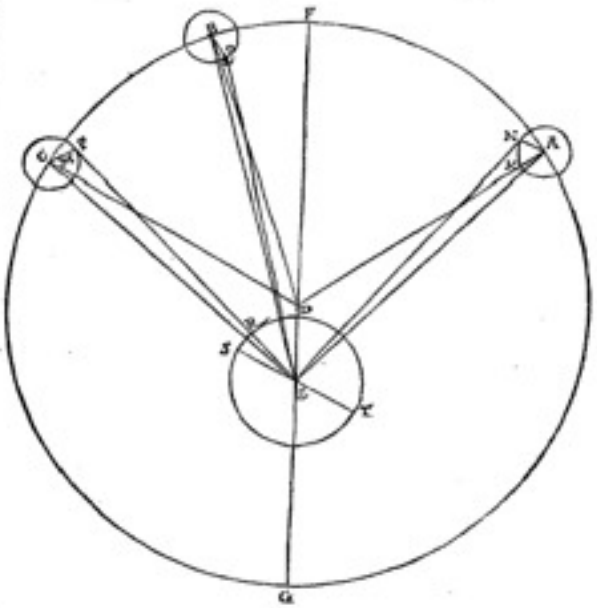
$$x / 365 = (\beta + \gamma) / 2\pi$$

$$x / 687 = \gamma / 2\pi$$

$$(\beta + \gamma)\, 365 = \gamma\, 687$$

	Distance		Period	
	Copernicus	**present**	**Copernicus**	**present**
Mercury	0,376	0,387	88^{d}	88^{d}
Venus	0,719	0,723	225^{d}	$224,7^{d}$
Earth	1	1	365.25^{d}	
Mars	1,520	1,524	687^{d}	687^{d}
Jupiter	5,219	5,203	12 yrs	11,86 yrs
Saturn	9,174	9,539	30 yrs	29,46 yrs

Verni, tunc existẽtis proueniret ad XXIII. gradum Scorpij, iuxta Ptolemæi sententiam. Erat enim locus stellæ apparens in hoc tertio acronychio, ut recitatum est, part. CCLXXVII. scrup. XIIII. quibus si auferantur part. LI. scrup. XIIII. iuxta angulum apparentiæ PDF ut demonstratũ est, remanet ipse locus summæ absidis eccentri in part. CCXXVI. scrup. XXIII. Explicetur iam q̃q; orbis terræ annuus, RST, qui secabit PR lineam, in R signo, & agat̃ dimetiens SET, iuxta CD lineam medij motus planetæ. Æqualibus igitur angulis SED, ipsi CDF, erit SER angulus



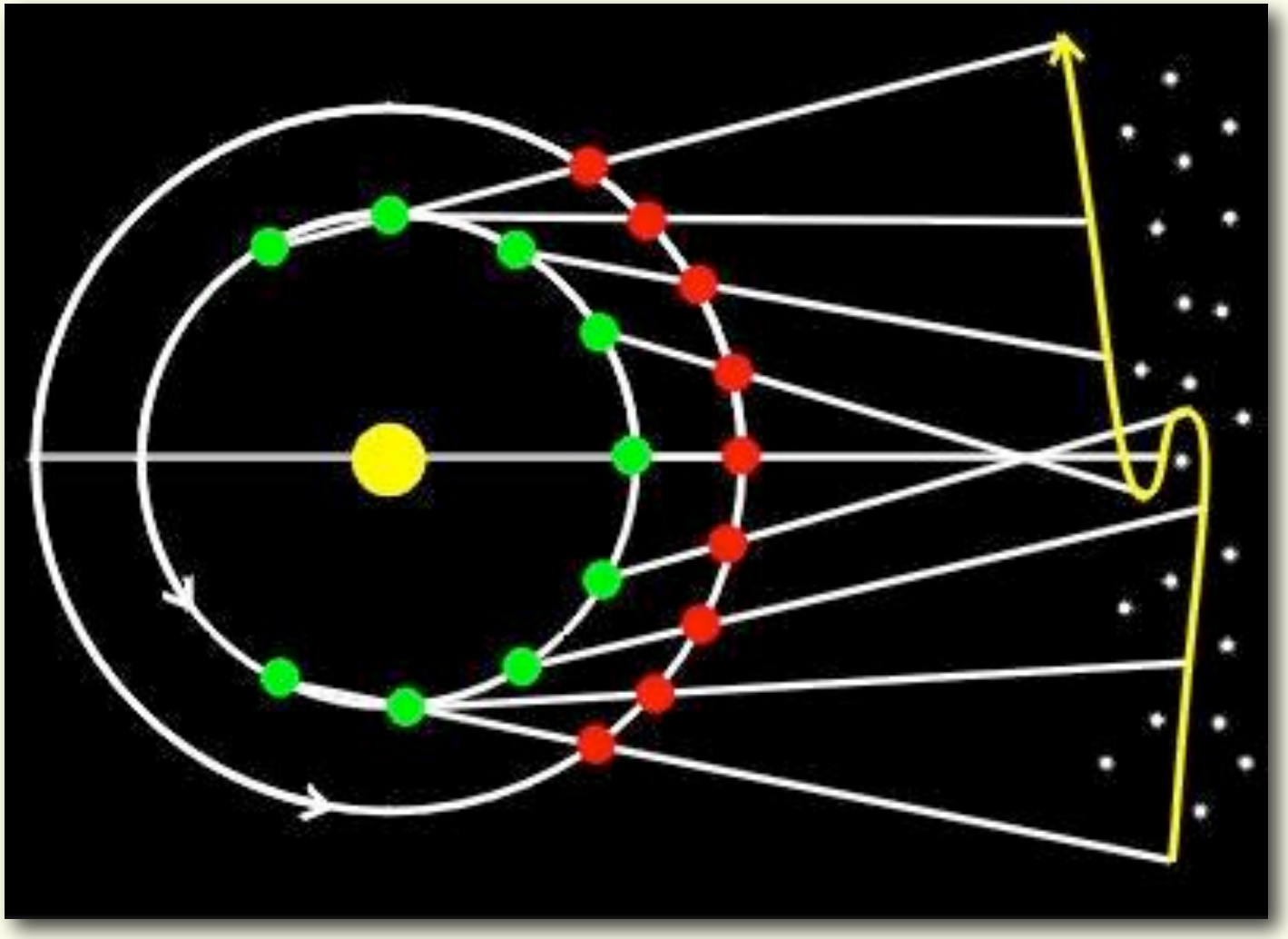
differentia & prosthaphæresis inter apparentem mediumq; motum, hoc est, inter CDF, & PED angulos partium V. scrup. XVI. atq; eadem inter medium uerumq; commmutationis motum, q̃ dempta ex semicirculo relinquit RT circumferẽtiã CLXXIIII. scrup. XLIIII. ac motum æqualem commutationis à signo T sumpto principio, id est, à media Solis & stellæ coniunctione usq; ad hanc tertiam noctis extremitatem, Siue ueram terræ & stellæ oppositionem. Habemus igitur iam, quod hora huius obseruationis, anno uidelicet XX. Imperij Adriani, Christi uero CXXXVI. octauo Idus Iulij, XI. horis à media nocte, anomaliã Saturni à summa abside eccentri sui part LVI. s. mediumq; motum commutationis part. CLXXIIII. scrup. XLIIII. Quæ demõstrasse propter sequentia fuerit opportunum.

Theory of Saturn according to Copernicus

The drawing shows only the orbit of the earth with its centre at *E* and the deferent of Saturn with its centre at *D*; *N*, *O* and *P* indicate three positions of the planet in its epicycle

The sun and other planets are not shown

Explanation of planetary loops in the Copernican system



”I myself consider that gravity is merely a certain natural inclination with which parts are imbued by the Architect of all things for gathering themselves together into unity and completeness by assembling into the form of a globe. It is easy to believe that the sun, moon and other luminaries among the wandering stars have this tendency also, so that by its agency they retain the rounded shape in which they reveal themselves, but nevertheless go round their orbits in various ways.”

Copernicus, *De revolutionibus*,
Book I, Ch. IX

”The principle of attraction, in the Newtonian sense of it, it seems was first surmised by Copernicus”

Ch. Hutton,
A Mathematical and Philosophical Dictionary,
v. 1, London, 1795

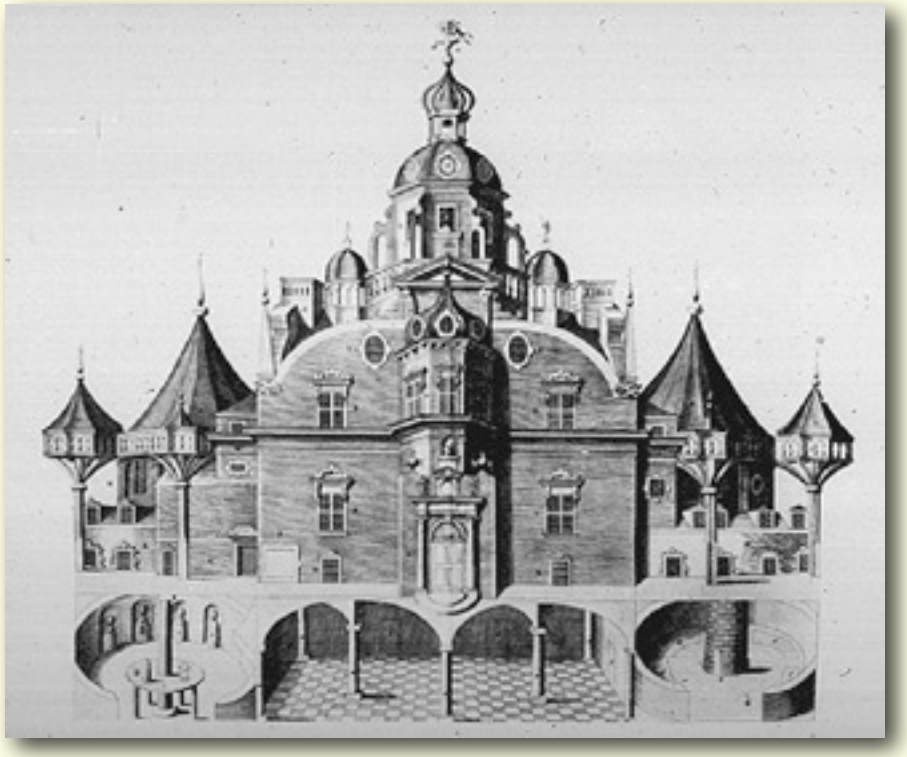
The system of Copernicus depicted in the *Atlas* of Cellarius (1661)

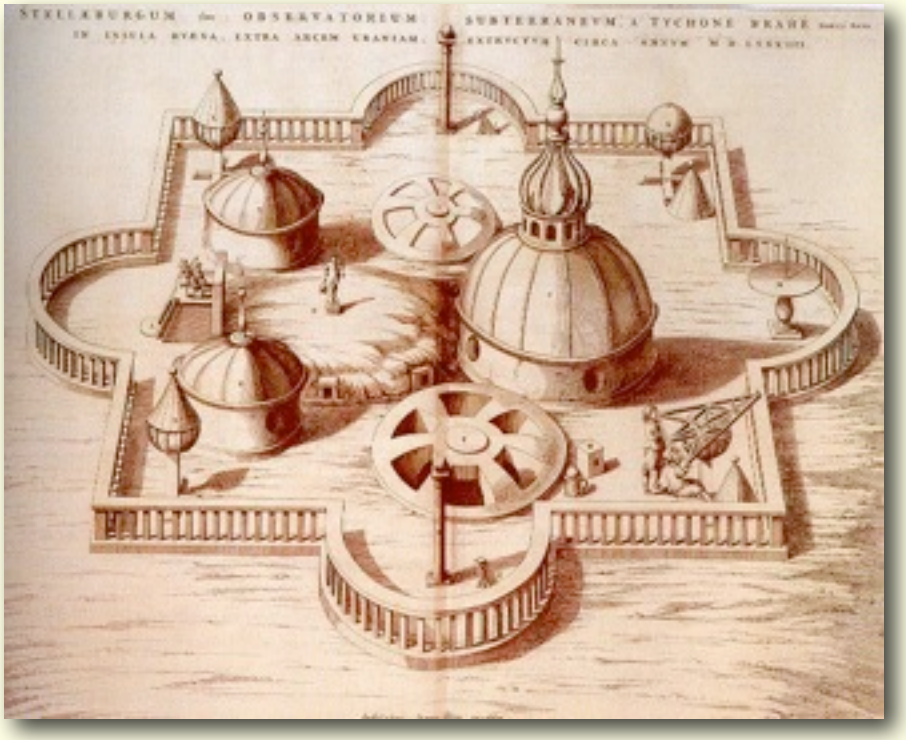
Tycho Brahe (1546-1601)

Astronomical observatories Uraniborg and Stjerneborg

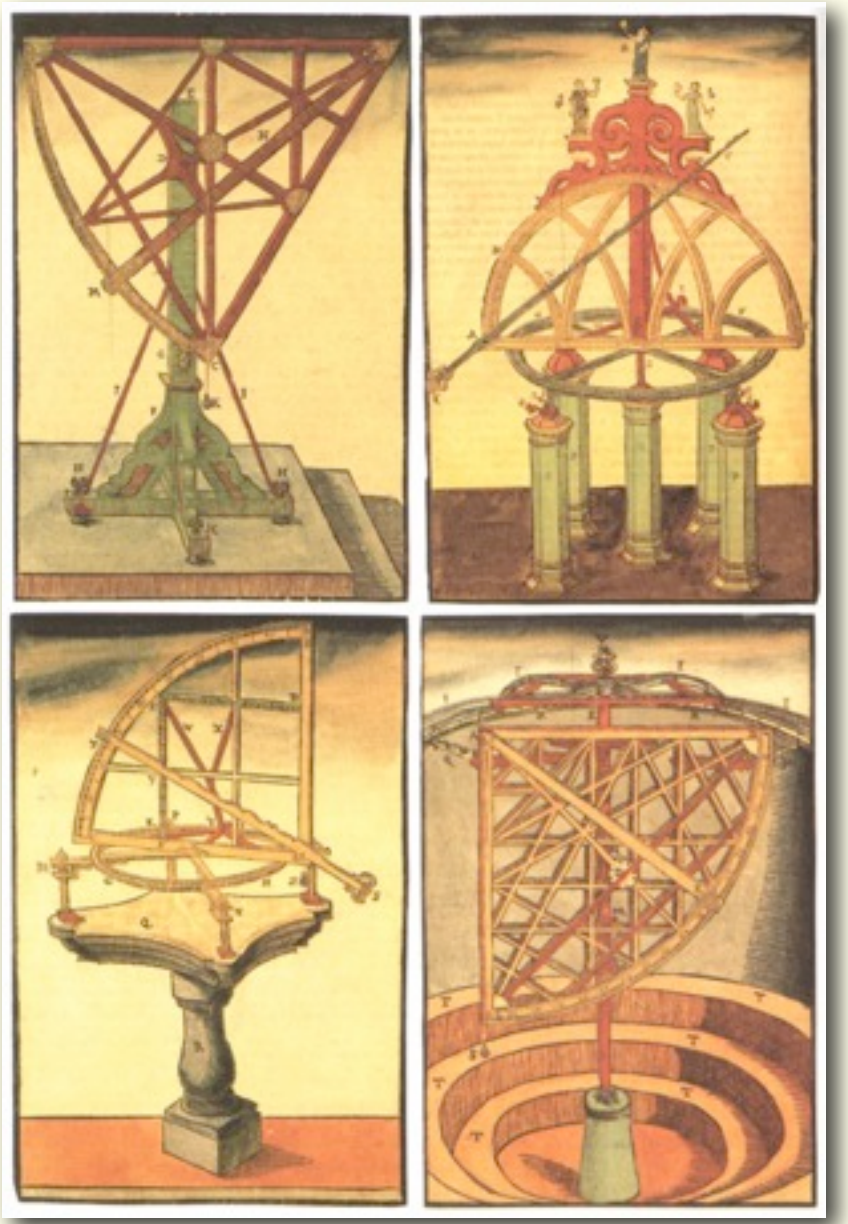
***De Stella Nova* (1572)**
***De Mundi aetherei recentioribus Phaenomenis* (1588)**
***Astronomiae Instauratae Mechanica* (1598)**
***Astronomiae Instauratae Progymnasmata* (1598-1602)**

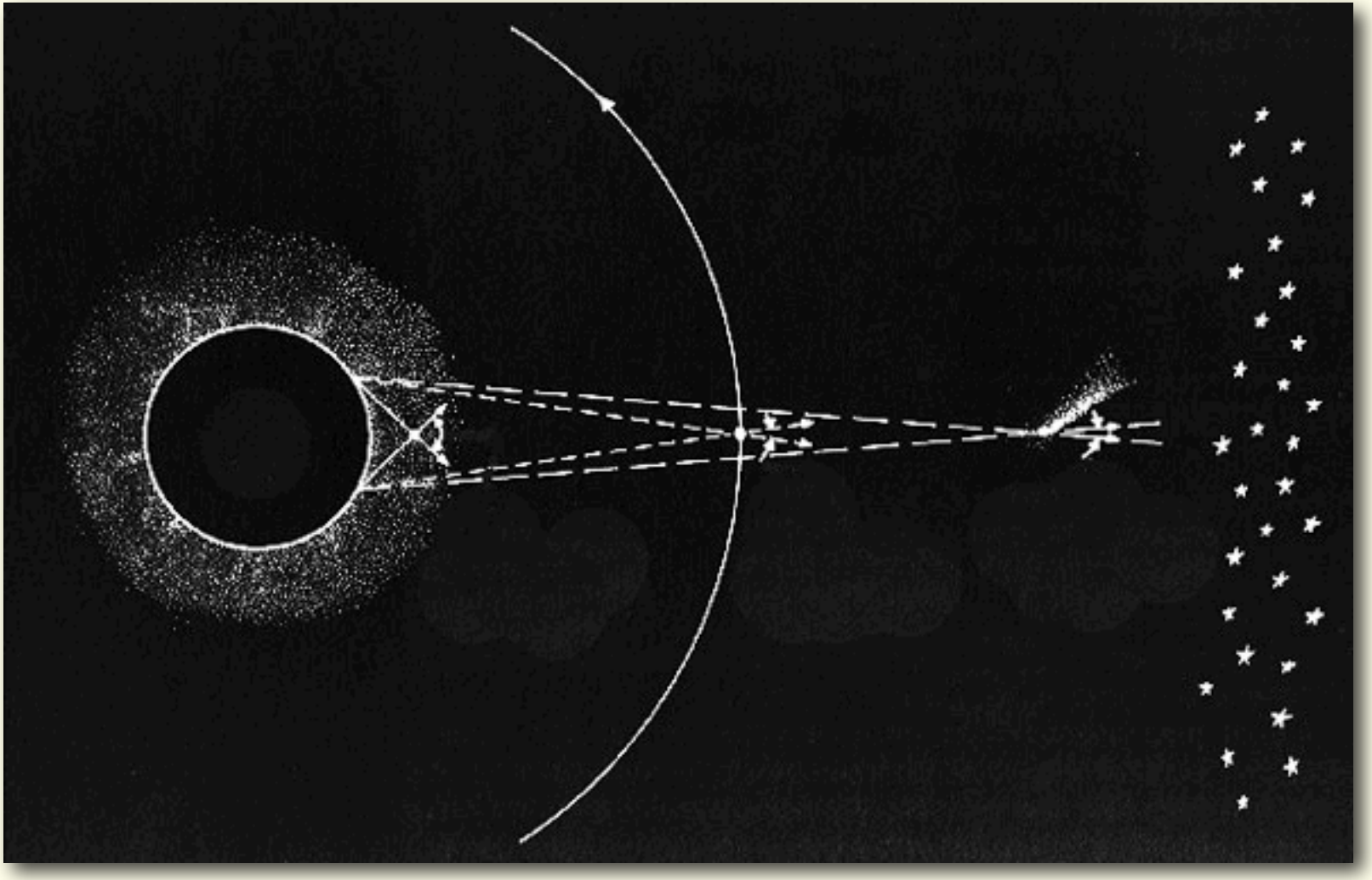
Tycho's observatories Uraniborg and Stjerneborg





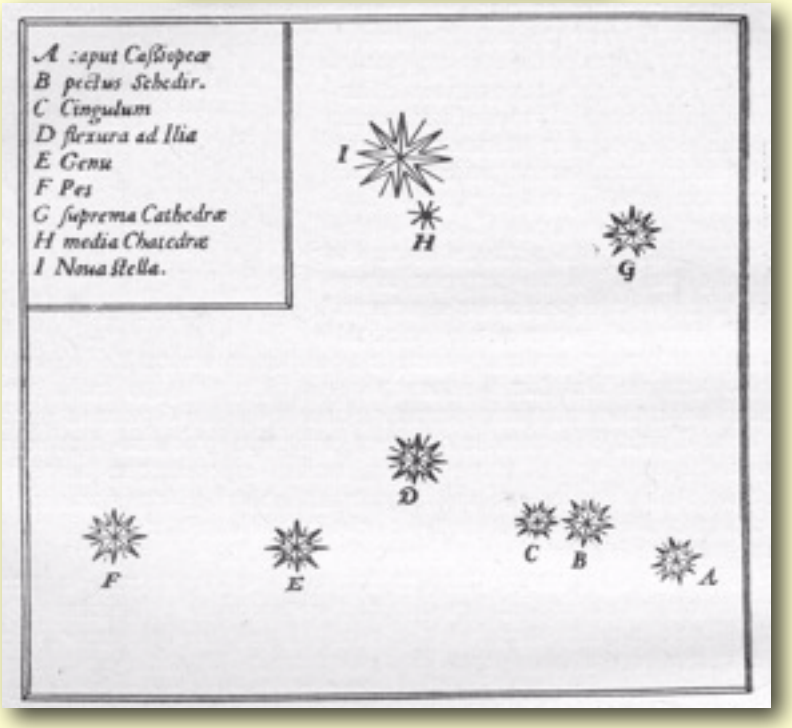
The instruments of Tycho Brahe



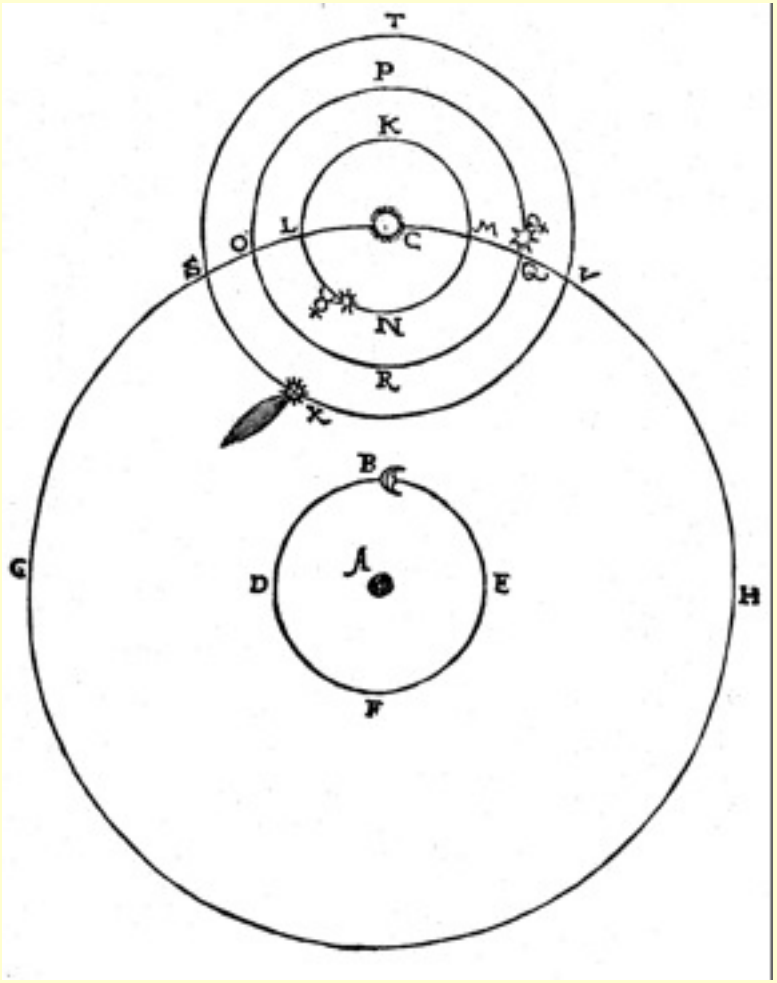


Tycho Brahe and measurements of a parallax

Tycho Brahe



New star of 1572



System of the world proposed by Tycho Brahe

Johannes Kepler

27 XII 1571	Born in Weil
1589-1594	Studied in Tübingen
1594-1600	Teacher in Graz
1596	*Mysterium Cosmographicum*
1600-1612	Prague
1604	*Ad Vitellionem paralipomena*
1604	*De stella nova*
1609	***Astronomia nova***
1611	*Dioptrices*
1612-1626	Linz
1618-1621	*Epitome astronomiae Copernicanae*
1619	***Harmonices mundi***
1626-1628	Ulm
1627	*Tabulae Rudolphinae*
1628-1630	Sagan
15 XI 1630	Died in Regensburg

Prodromus

DISSERTATIONVM COSMOGRAPHICARVM, CONTINENS MYSTERIVM COSMOGRAPHICVM,

DE ADMIRABILI PROPORTIONE ORBIVM COELESTIVM, DEQVE CAVSIS

cœlorum numeri, magnitudinis, motuumque periodicorum genuinis & proprijs,

DEMONSTRATVM, PER QVINQVE regularia corpora Geometrica,

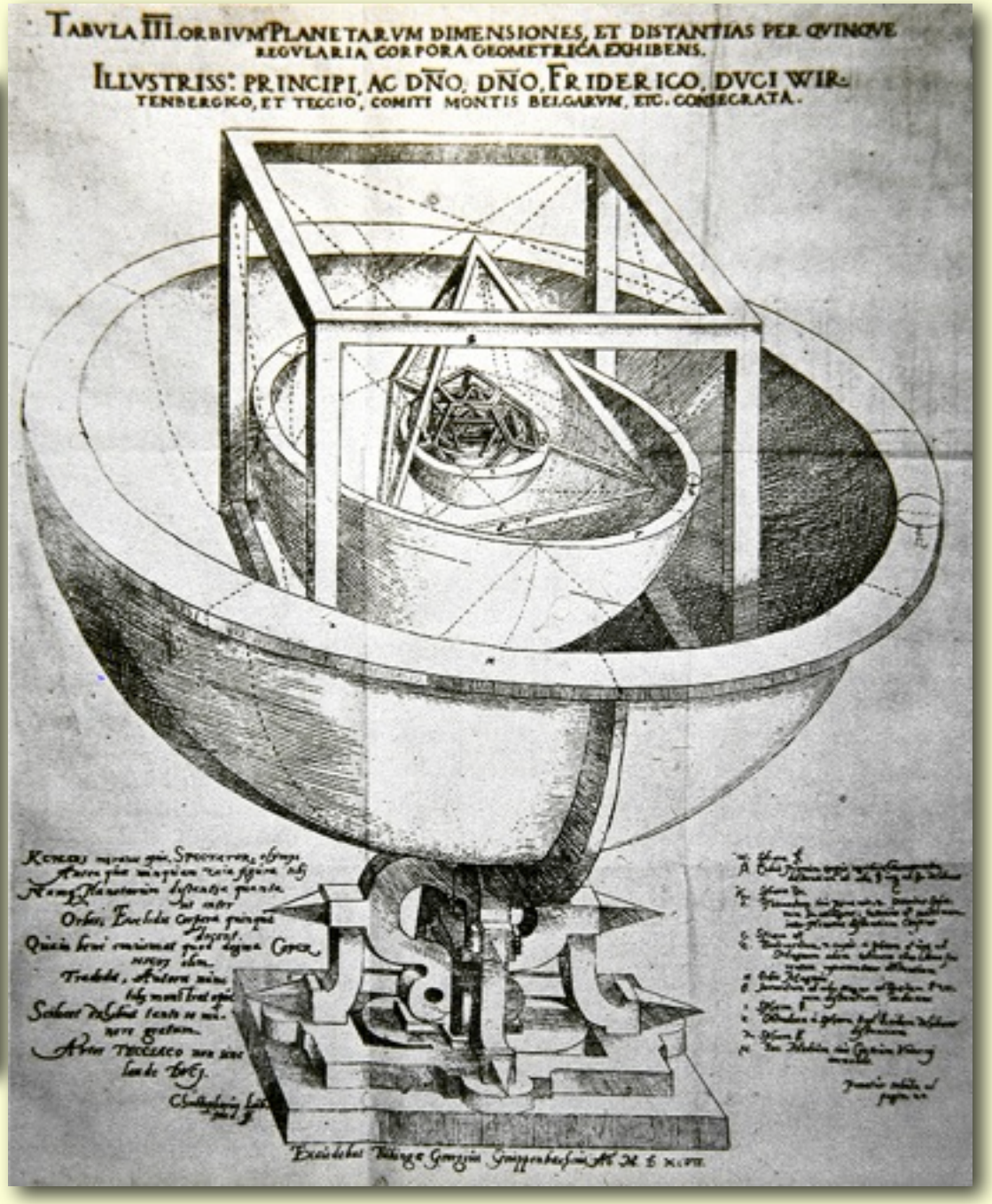
A

M. IOANNE KEPLERO, VVIRTEMbergico, Illustrium Styriæ prouincialium Mathematico.

Quotidiè morior, fateorque: sed inter Olympi
Dum tenet assiduas me mea cura vias:
Non pedibus terram contingo: sed ante Tonantem
Nectare, diuina pascor & ambrosiâ.

Additus est erudita NARRATIO M. GEORGII IOACHIMI RHETICI, de Libris Reuolutionum, atq; admirandis de numero, ordine, & distantijs Sphærarum Mundi hypothesibus, excellentissimi Mathematici, totiusq; Astronomiæ Restauratoris D. NICOLAI COPERNICI.

TVBINGÆ
Excudebat Georgius Gruppenbachius,
ANNO M. D. XCVI.



”Dear Reader, it is my intention in this small treatise to show that the almighty and infinitely merciful God, when he created our moving world and determined the order of the celestial bodies, took as the basis for his construction the five regular bodies which have enjoyed such great distinction from the time of Pythagoras and Plato down to our own days, and that he coordinated in accordance with their properties the number and proportions of the celestial bodies, as well as the relationships between the various celestial motions.”

Kepler, *Mysterium cosmographicum*

”The Earth is the measure for all the other spheres. Circumscribe a Dodecahedron about it, then the surrounding sphere will be that of Mars; circumscribe a Tetrahedron about the sphere of Mars, then the surrounding sphere will be that of Jupiter; circumscribe a Cube about the sphere of Jupiter, then the surrounding sphere will be that of Saturn. Now place an Icosahedron within the sphere of Earth, then the sphere which is inscribed is that of Venus; place an Octahedron within the sphere of Venus, and the sphere which is inscribed is that of Mercury. There you have the reason for the number of the planets.”

Kepler, *Mysterium cosmographicum*

Kepler, *Harmonices Mundi*, Book 5

The order of planets

Saturn

Cube

Jupiter

Tetrahedron

Mars

Dodecahedron

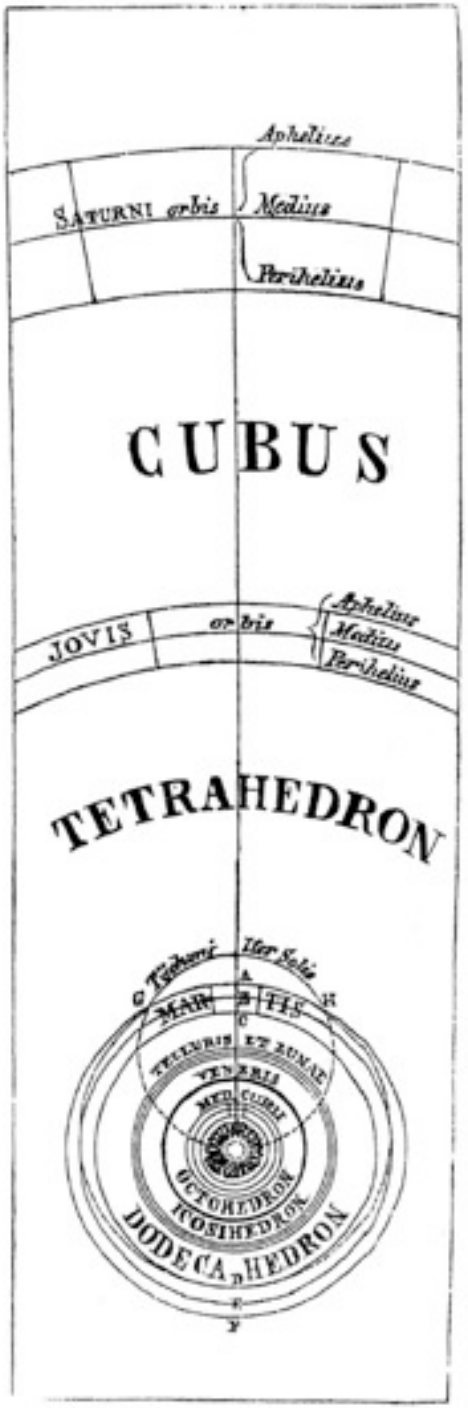
Earth

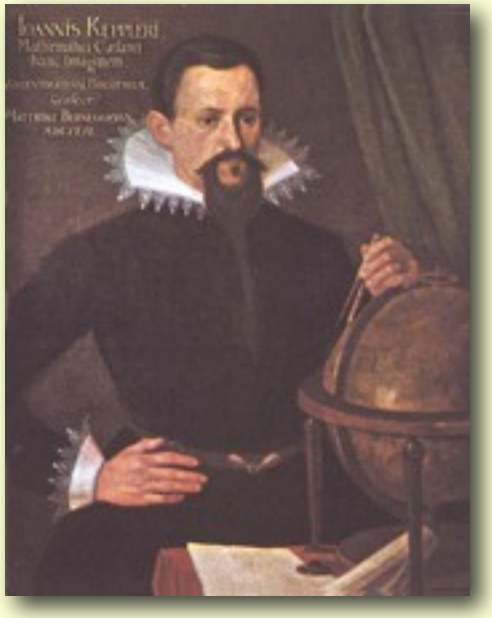
Icosahedron

Venus

Octahedron

Mercury





”There were three things above all others the cause of which I sought without wearying, namely, the number, size and motion of the orbits.”

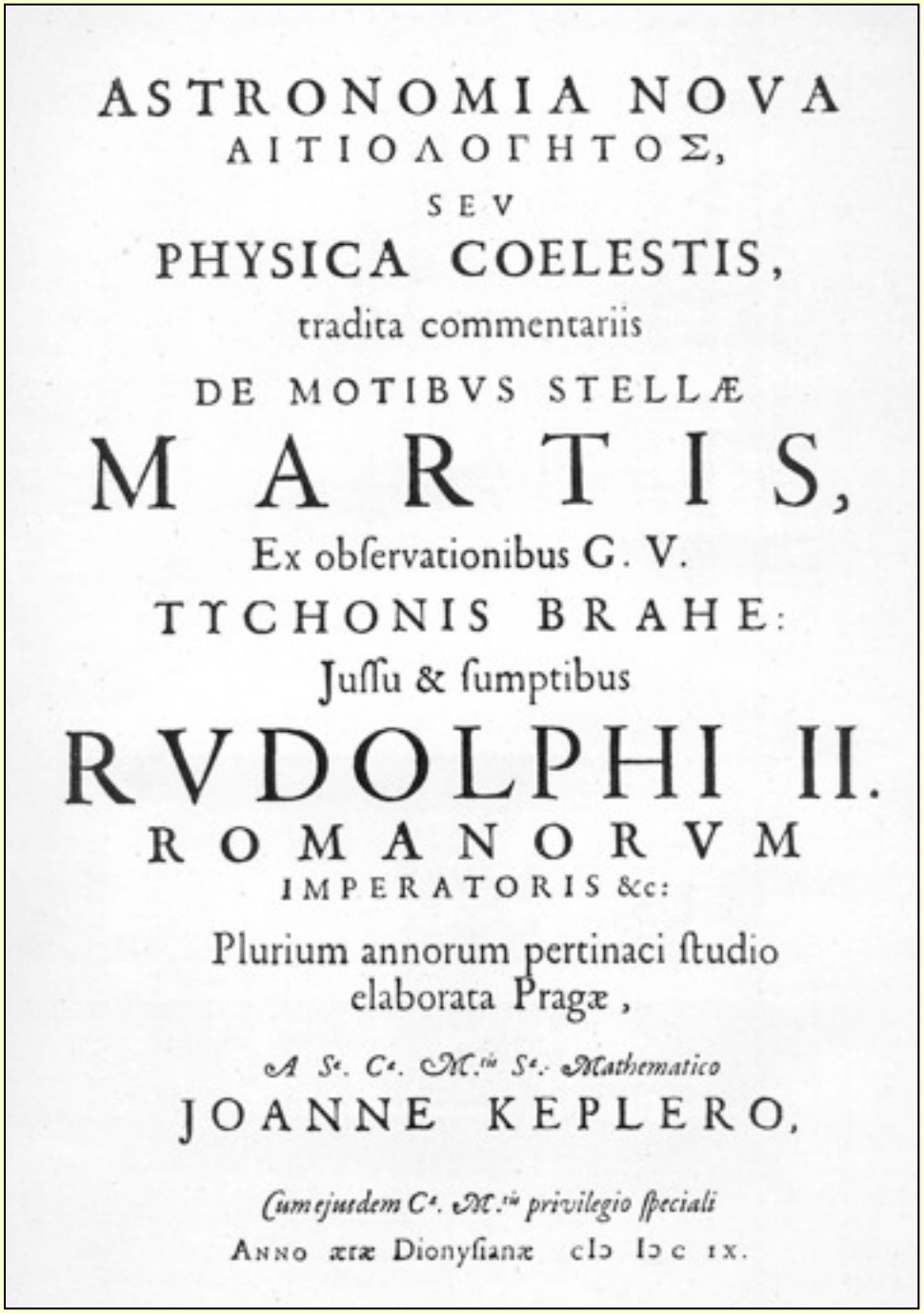
Kepler – *Mysterium cosmographicum*

”I built my whole astronomy
upon Copernicus’ hypotheses concerning the world,
upon the observations of Tycho Brahe, and lastly
upon the Englishman, William Gilbert’s philosophy of
magnetism.”

Epitome astronomiae Copernicanae, Book IV

”The reflective and intelligent reader will see, that this opinion among astronomers concerning the perfect eccentric circle of the orbit involves a great deal that is incredible in physical speculation... My first error was to take the planet’s path as a perfect circle, and this mistake robbed me of more time, as it was taught on the authority of all philosophers, and consistent in itself with Metaphysics.”

Kepler, *Astronomia nova* (1609)



ASTRONOMIA NOVA
AITIOΛOΓHTOΣ,
SEV
PHYSICA COELESTIS,
tradita commentariis
DE MOTIBVS STELLÆ
MARTIS,
Ex obſervationibus G. V.
TYCHONIS BRAHE:
Juſſu & ſumptibus
RVDOLPHI II.
ROMANORVM
IMPERATORIS &c:
Plurium annorum pertinaci ſtudio
elaborata Pragæ,
A Sᵉ. Cᵉ. Mᵗⁱ Sᵉ. Mathematico
JOANNE KEPLERO,
Cum ejuſdem Cᵉ. Mᵗⁱ privilegio ſpeciali
Anno æræ Dionyſianæ clɔ Iɔc ix.

New astronomy
based on causes,
or celestial physics,
explained in
commentaries
on the motions of the star
Mars,
from the observations
of the noble Tycho Brahe,
by the order and expense
of the Roman Emperor
Rudolph II
...

”A mathematical point, be it the centre of the world or not, cannot move heavy bodies... As for the true theory of gravity, it is based upon these axioms: all corporeal substance insofar as it is corporeal is apt to remain at rest at any place in which it is placed alone, outside of the virtue of a cognate body...Gravity is a mutual corporeal affection of cognate bodies toward their reunion or conjunction (of a similar kind is also the magnetic faculty) such that the Earth drags the stone much more that the stone tends towards the Earth. Heavy bodies (even if we place the Earth in the centre of the world) do not move toward the centre of the world as to the centre of the world, but toward the centre of a cognate round body, that is, the Earth.”

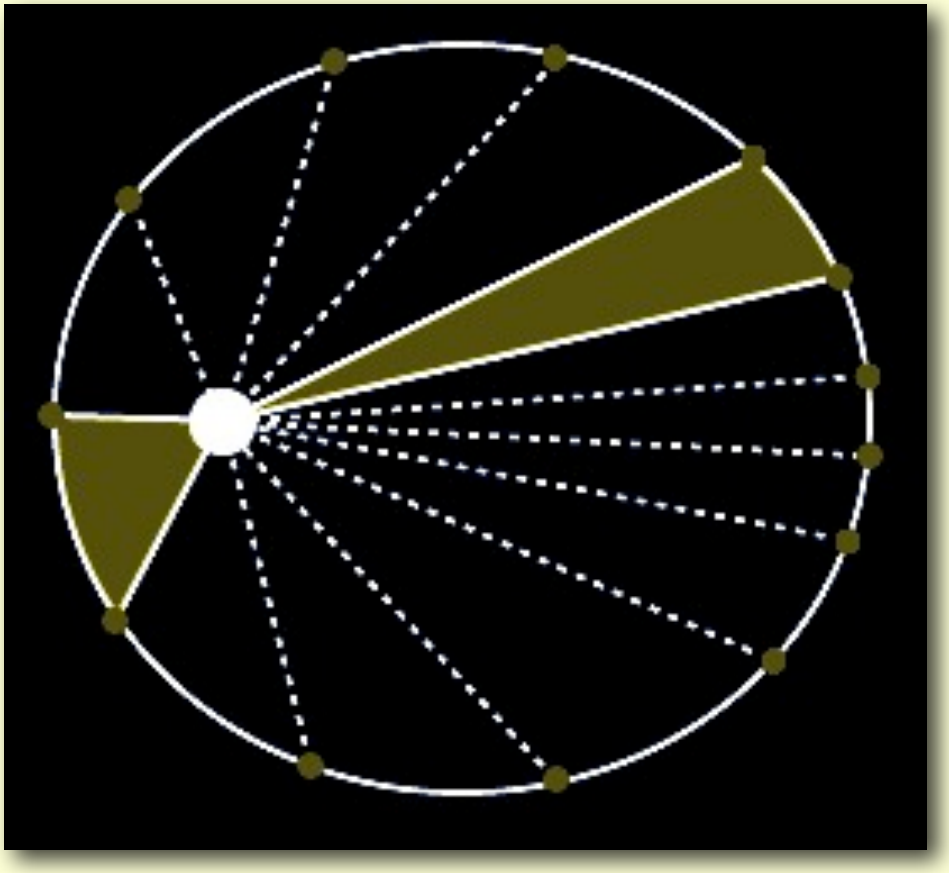
Kepler, *Astronomia nova*, Introduction

”If two stones were placed in a certain place of the world, near each other and outside the orb of the virtue of a third cognate body, these stones, in a manner similar to two magnetic bodies, would meet in an intermediate place, each nearing the other by an interval proportional to the bulk of the other.

If the Moon and the Earth were not retained each in its circuit by an animal [vital] force, or by some other, equivalent, the Earth would ascend toward the Moon by a fifty-fourth part of the interval [separating them] and the Moon would descend by fifty-three parts, or about, of this interval; provided, however, that their substance is of the same density.”

Astronomia nova, 1609

Kepler's second law (law of areas)



The radius vector (the line from the sun to the planet) to a planet sweeps out equal areas in equal intervals of time as the planet revolves in its orbit

"With your ellipse you abolish the circularity and uniformity of the motions, which appears to me the more absurd the more profoundly I think about it... If you could only preserve the perfect circular orbit, and justify your elliptic orbit by another little epicycle, it would be much better."

David Fabricius to Kepler, January 20, 1607

”Concerning the motion of the moon you write you have traced all the inequalities to physical causes; I do not quite understand this. I think rather that one should leave physical causes out of account, and should explain astronomical matters only according to astronomical method with the aid of astronomical, not physical, causes and hypotheses. That is, the calculation demands astronomical bases in the field of geometry and arithmetic...”

Michael Mästlin to Kepler, October 1, 1616

”In trying to prove the Copernican hypothesis from physical causes, Kepler introduces strange speculations which belong not in the domain of astronomy, but of physics”

Petrus Crüger, Dantisci (Piotr Krüger, Gdańsk)

Ioannis Keppleri

HARMONICES MVNDI

LIBRI V. QVORVM

Primus GEOMETRICVS, De Figurarum Regularium, quæ Proportiones Harmonicas constituunt, ortu & demonstrationibus.

Secundus ARCHITECTONICVS, seu ex GEOMETRIA FIGVRATA, De Figurarum Regularium Congruentia in plano vel solido:

Tertius propriè HARMONICVS, De Proportionum Harmonicarum ortu ex Figuris: deque Naturâ & Differentiis rerum ad cantum pertinentium, contra Veteres:

Quartus METAPHYSICVS, PSYCHOLOGICVS & ASTROLOGICVS, De Harmoniarum mentali Essentiâ earumque generibus in Mundo; præsertim de Harmonia radiorum, ex corporibus cœlestibus in Terram descendentibus, eiusque effectu in Natura seu Anima sublunari & Humana:

Quintus ASTRONOMICVS & METAPHYSICVS, De Harmoniis absolutissimis motuum cœlestium, ortuque Eccentricitatum ex proportionibus Harmonicis.

Appendix habet comparationem huius Operis cum Harmonices Cl. Ptolemæi libro III. cumque Roberti de Fluctibus, dicti Flud. Medici Oxonienſis ſpeculationibus Harmonicis, operi de Macrocoſmo & Microcoſmo inſertis.

ACCESSIT NVNC PROPTER COGNATIONEM MATERIÆ eiuſdem Authoris liber ante 23. annos editus Tubingæ, cui titulus Prodromus, *ſeu Myſterium Coſmographicum, de cauſis Cælorum Numeri, Proportionis motuumque Periodicorum, ex quinque Corporibus Regularibus.*

Cum S. C. Mtis. Priuilegio ad annos XV.

Lincii Auſtriæ,

Sumptibus GODOFREDI TAMPACHII Bibl. Francof.
Excudebat IOANNES PLANCVS.

ANNO M. DC. XIX.

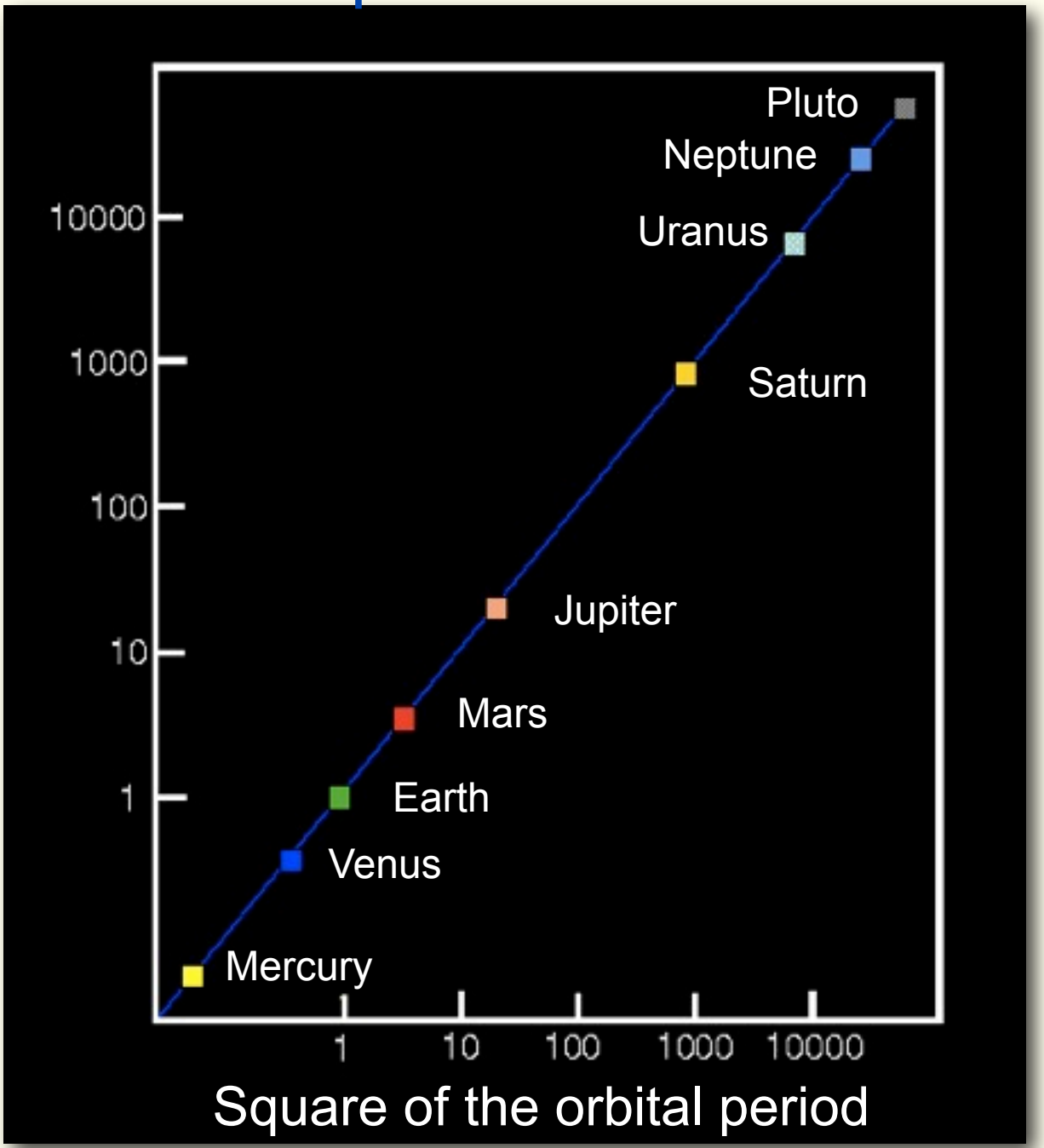
”For after finding the true intervals of the spheres by the observations of Tycho Brahe and continuous labour and much time, at last, at last the right ratio of the periodic times to the spheres though it was late, looked to the unskilled man, yet looked at him, and, after much time, came, and, if you want the exact time, was conceived mentally on the 8th of March in this year One Thousand Six Hundred and Eighteen but unfelicitously submitted to calculation and rejected as false, finally, summoned back on the 15th of May, with a fresh assault undertaken, outfought the darkness of my mind by the great proof afforded by my labor of seventeen years on Brahe’s observations and meditation upon it uniting in one concord, in such fashion that I first believed I was dreaming and was presupposing the object of my search among the principles. But it is absolutely certain and exact that the ratio which exists between the periodic times of any two planets is precisely the ratio of the 3/2th power of the mean distances, i.e., of the spheres themselves; provided, however, that the arithmetic mean between both diameters of the elliptic orbit be slightly less than the longer distance.”

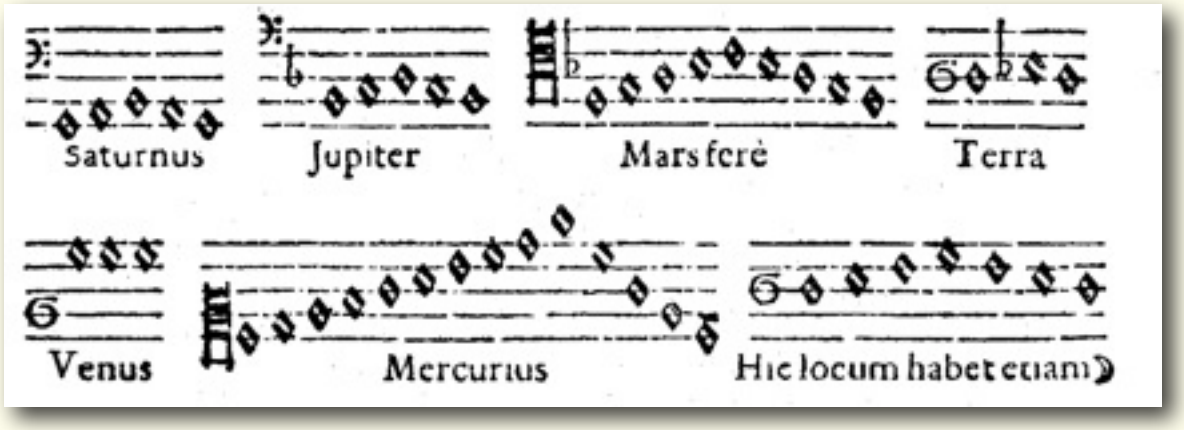
Kepler, *Harmonices Mundi*, Book. 5, Ch. 8

”And so if any one take the period, say, of the earth, which is one year, and the period of Saturn, which is thirty years, and extract the cube roots of this ratio and then square the ensuing ratio by squaring the cube roots, he will have as his numerical products the most just ratio of the distances of the earth and Saturn from the sun. For the cube root of 1 is 1, and the square of it is 1; and the cube root of 30 is greater than 3, and therefore the square of it is greater than 9. And Saturn, at its mean distance from the sun, is slightly higher than nine times the mean distance of the earth from the sun.”

Kepler*, Harmonices Mundi*, Book. 5, Ch. 8

Kepler's third law



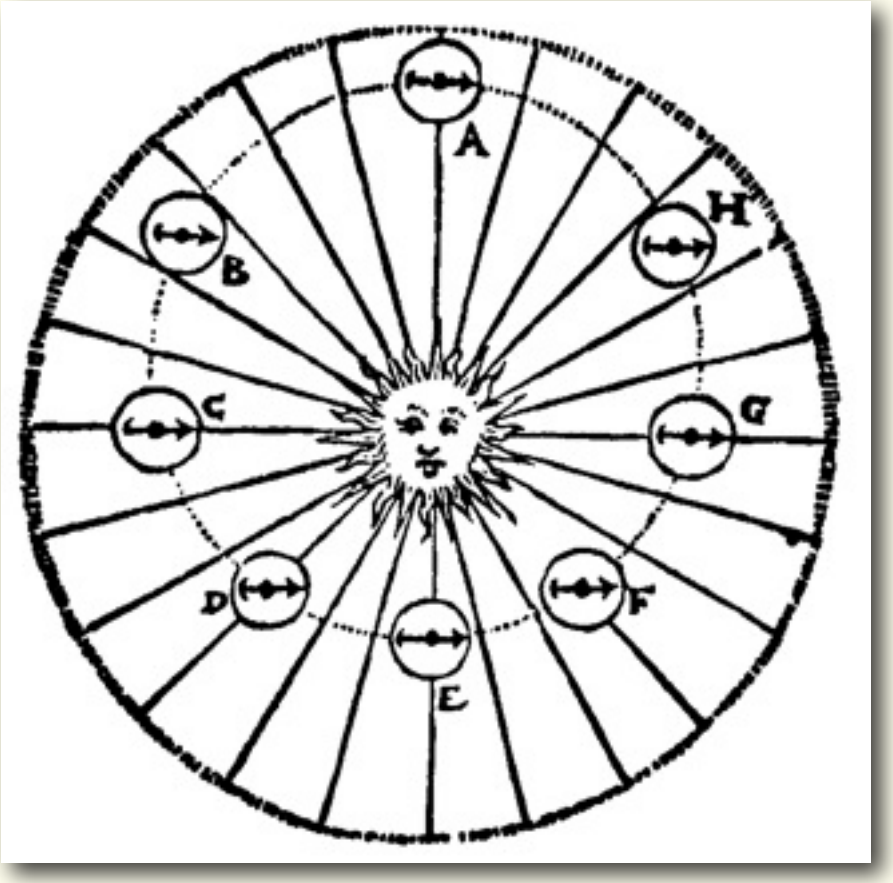


”Tellus canit MI, FA, MI, ut vel ex syllaba conjicias, in hoc nostro domicilio MIseriam ut FAmen obtinere.”

(The Earth sings MI, FA, MI so that you may infer even from the syllables that in this our domicile MIsery and FAmine obtain.)

Kepler, *Harmonices Mundi,* Book V, Ch.6.

Kepler's explanation of elliptical orbits by magnetic forces



Epitome astronomiae Copernicanae

Progress in the science of magnetism

PETRI PEREGRINI
MARICVRTENSIS
De Magnete, seu Rota perpetui motus, libellus.
Diui FERDINANDI Rhomanorum Imperatoris auspicio, per Achillem P: Gasserum L: nunc primum promulgatus.

AVGSBVRGI IN SVEVIS.
Anno Salutis
1558.

THE
newe Attractiue,

Containyng a short discourse of the *Magnes* or *Lodestone*, and amongest other his vertues, of a newe discouered secret and subtill propertie, concernyng the Declinyng of the Needle, touched therewith vnder the plaine of the Horizon.
Now first founde out by *Robert Norman* Hydrographer.

¶ Herevnto are annexed certaine necessarie rules for the art of Nauigation, by the same *R. N.*

¶ *Imprinted at London by Iohn Kyngston for Richard Ballard.*
1581.

Giambattista della Porta (1535-1615)

IO. BAPTISTAE PORTÆ NEAPOLITANI, MAGIÆ NATVRALIS LIBRI VIGINTI,

IN QVIBVS SCIENTIARVM Naturalium diuitiæ, & deliciæ demonstrantur.

Iam de nouo, ab omnibus mendis repurgati, in lucem prodierunt.

Librorum ordinem, qui in hoc opere continentur, versa pagina indicabit.

FRANCOFVRTI

Apud Andreæ Wecheli heredes, Claudium Marnium, & Ioann. Aubrium.

M D XCVII.

MAGIÆ NATVR. LIB. VII.

DE MIRABILIB. MAGNETIS.

NATURAL

MAGICK

BY

John Baptista Porta,

A NEAPOLITANE:

IN

TWENTY BOOKS:

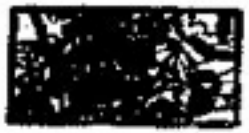
1 Of the Causes of Wonderful things.
2 Of the Generation of Animals.
3 Of the Production of new Plants.
4 Of increasing Houshold-Stuff.
5 Of changing Metals.
6 Of counterfeiting Gold.
7 Of the Wonders of the Loadstone.
8 Of strange Cures.
9 Of Beautifying Women.
10 Of Distillation.
11 Of Perfuming.
12 Of Artificial Fire.
13 Of Tempering Steel.
14 Of Cookery.
15 Of Fishing, Fowling, Hunting, &c.
16 Of Invisible Writing.
17 Of Strange Glasses.
18 Of Statick Experiments.
19 Of Pneumatick Experiments.
20 Of the Chaos.

Wherein are set forth

All the RICHES and DELIGHTS

Of the

NATURAL SCIENCES.



LONDON,

Printed for *Thomas Young*, and *Samuel Speed*; and are to be sold at the three Pigeons, and at the Angel in St. Paul's Church-yard. 1658.

Giambattista della Porta – *Magia naturalis,*
Book VII, Chapter XLVIII

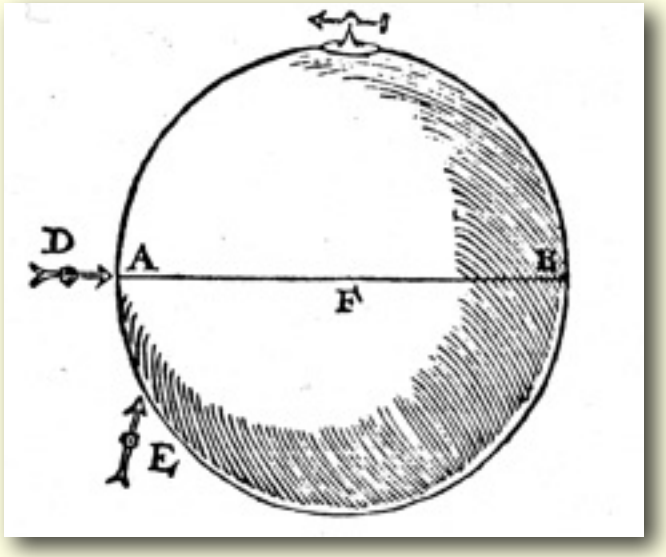
Whether Garlic can hinder the Virtues of the Loadstone

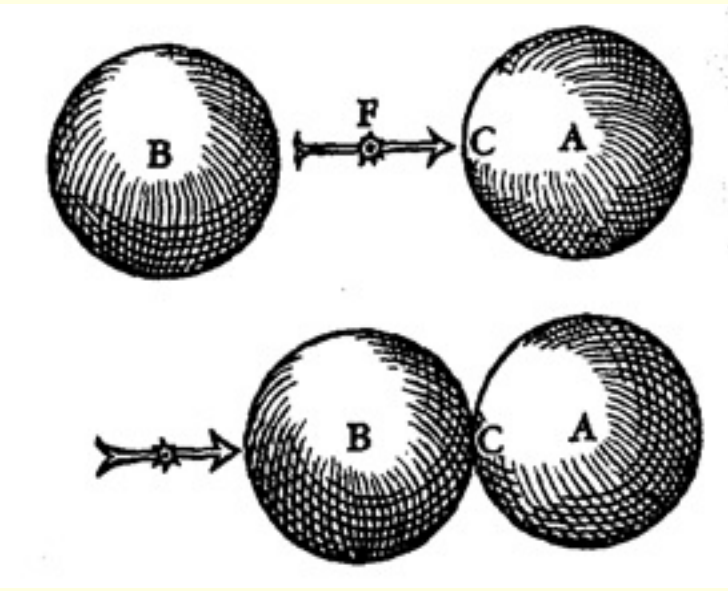
”Now I shall pass on to other properties of the Loadstone. And first, whether the Loadstones attraction can be in any way hindered. Plutarch says, that Garlic is at great enmity with the Loadstone. And such antipathy and hatred there is between these insensible creatures, that if the Loadstone be smeared with Garlic, it will drive away Iron from it. Ptolemy confirms the same. That the Loadstone will not draw Iron, if it be anointed with Garlic... It is a common opinion among Seamen, that Onions and Garlic are at odds with the Loadstone...”

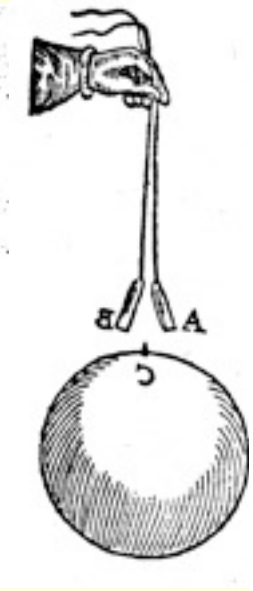
Giambattista della Porta – *Magia naturalis,* Book VII, Chapter XLVIII

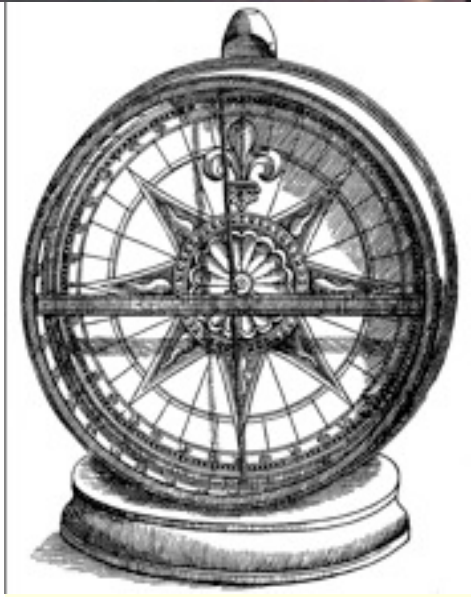
"...But when I tried all these things, I found them to be false. For not only breathing and belching upon the Loadstone after eating Garlic, did not stop its Virtues. But when it was all anointed over with the juice of Garlic, it did perform its office as well as if it had never been touched with it. And I could observe almost not the least difference, lest I should seem to make void the endeavors of the Ancients. And again, when I inquired of Mariners, whether it were so, that they were forbid to eat Onions and Garlic for that reason. They said, they were old wives fables, and things ridiculous. And that Seamen would sooner lose their lives, than abstain from eating Onions and Garlic."

William Gilbert (1544-1603)









Three editions of Gilbert's *De magnete*


GVILIELMI GIL
BERTI COLCESTREN-
SIS. MEDICI LONDI-
NENSIS,

DE MAGNETE. MAGNETI-
CISQVE CORPORIBVS ET DE MAG-
no magnete tellure; Physiologia noua,
plurimis & argumentis, & repe-
rimentis demonstrata.

LONDINI
EXCVDEBAT PETRVS SHORT ANNO
MDC.


LACTANTIVS

Siue
PHYSIOLOGIA NOVA
DE MAGNETE,
MAGNETICISQVE CORPO-
RIBVS ET MAGNO MAGNETE
Tellure Sex libris comprehensa
A
Guilielmo Gilberto Colcestrensi,
Medico Londinensi,
In quibus ea, quæ ad hanc materiam spectant, pluri-
bis & argumentis ac experimentis quàm fieri
absolutissimè potuerunt tractantur & explicantur.
Omnia nunc diligenter recognita & emen-
datiora quam ante in lucem edita, aucta & figu-
ris illustrata operâ & studio
Wolfgangi Lochmanni I.V.D.
& Mathematici.
Ad calcem libri adiunctus est Index Capi-
tum Rerum et Verborum locupletissimus
EXCVDVS SEDINI
Typis Gotzianis Sumptibus
Authoris
Anno M.DC.XXVII.


Tractatus, siue Physiologia Noua
DE
MAGNETE,
Magneticisq; corporibus & magno
Magnete tellure, sex libris comprehensus.
A GVILIELMO GILBERTO Colce-
strensi, Medico Londinensi.

In quibus ea, quæ ad hanc materiam spectant, plurimis
& Argumentis & experimentis exactissime absolutiss-
mè tractantur & explicantur.

Omnia nunc diligenter recognita, & emendatius quam ante
in lucem edita, aucta & figuris illustrata, opera & studio D.
WOLFGANGI LOCHMANNI, I. V. D.
& Mathematici.

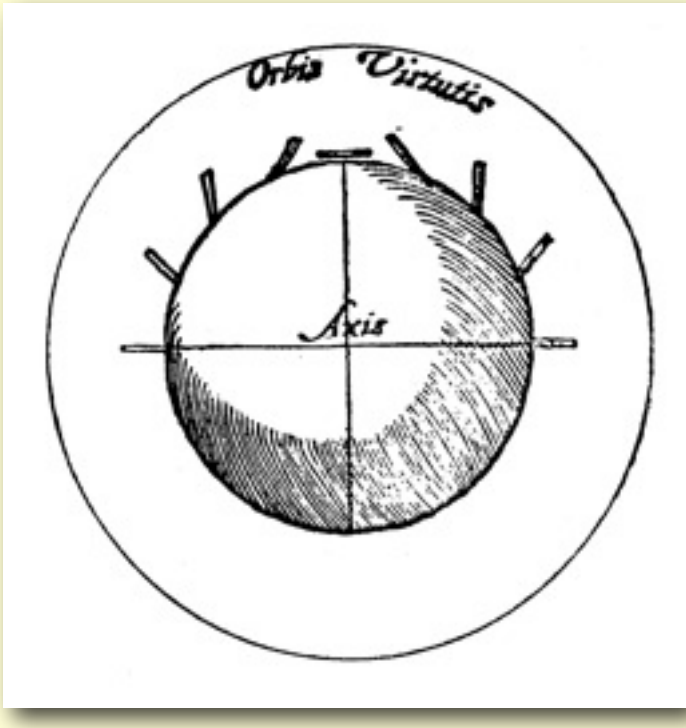
Ad calcem libri adiunctus est Index capitum, Rerum & Verborum
locupletissimus, qui in priore editione desiderabatur.

SEDINI,
Typis GOTZIANIS.
ANNO M. DC. XXXIII.

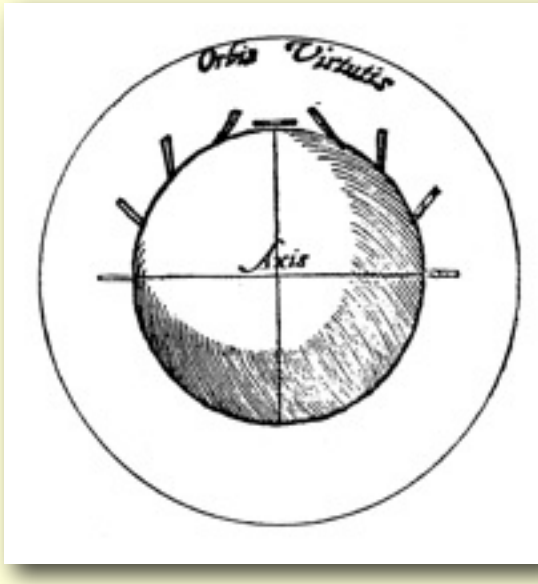
William Gilbert (1544-1603)

”The terrella sends its force abroad in all directions, according to its energy and its quality. But whenever iron or other magnetic body of suitable size happens within its sphere of influence it is attracted; yet the nearer it is to the loadstone the greater the force with which it is borne toward it. Such bodies tend to the loadstone not as toward a centre nor towards its centre: that they do only at its poles...”

De magnete, Book II, Chapter 6



William Gilbert, *De magnete*, Book II



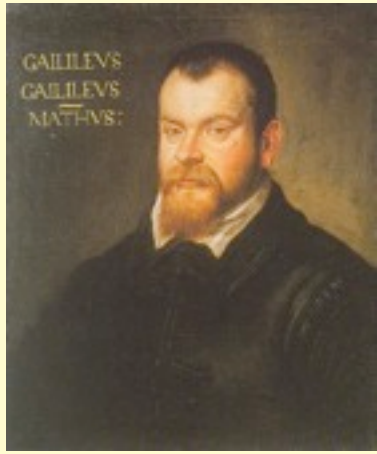
”The magnetic force is given out in all directions around the body; around the terrella it’s given out spherically; around loadstones of other shapes unevenly and less [...] The loadstone simply excites magnetic bodies situated at convenient distance. And as light – so opticians tell us – arrives instantly in the same way, with far greater instantaneousness, the magnetic energy is present within the limits of its force; and because its act is far more subtile than light, and it does not accord with non-magnetic bodies, it has no relations with air, water, or other non-magnetic body [...] And as light impinges on whatever confronts it, so does the loadstone impinge upon a magnetic body and excites it.”

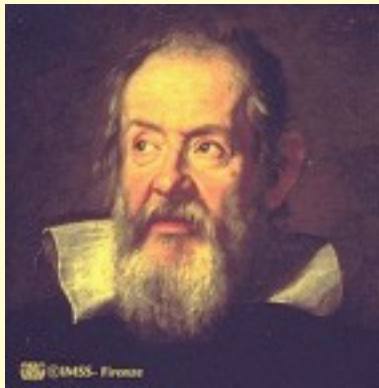
„Here we must express wonder at a manifest error of Baptista Porta, who though he properly refuses assent to the inveterate falsehood about the force the opposite of the magnetic, imparts a still falser opinion, to wit that iron rubbed with diamond turns to the north. ‘If – he writes – we rub an iron needle on diamond, and then put it in a boat or on a straw or suspend it properly with a thread, at once it turns to the north like iron rubbed on a lodestone, or perhaps a little more sluggishly’ [...]. Now this is contrary to our magnetic rules, and hence we made the experiment ourselves with seventy-five diamonds in presence of many witnesses, employing a number of iron bars and pieces of wire, manipulating them with the greatest care while they floated in water, supported by corks; yet never was it granted me to see the effect mentioned by Porta.”

De magnete, Book III, Ch. 13

Galileo Galilei

15 II 1564	Born in Pisa
1581	Began studies in Pisa
1589-1592	Professor in Pisa
1592-1610	Professor in Padua
1609	Constructed telescope
7 I 1610	Discovery of ”Medicean Stars”
III 1610	***Sidereus nuncius***
from 1610	Court mathematician of the Grand Duke of Tuscany
1613	***Istoria e dimostrazioni intorno alle macchie solari***
1623	***Il Saggiatore***
1632	***Dialogo***
22 VI 1633	Condemnation
1638	***Discorsi e dimostrazioni***
8 I 1642	Died in Arcetri





”You must know then, that it is nearly two months since news was spread here that in Flanders there had been presented to Count Maurice a spy-glass, made in such a way that very distant things are made by it to look quite close, so that a man two miles away can be distinctly seen. This seemed to me so marvellous an effect that it gave to me occasion for thought; and as it appeared to me that it must be founded on the science of perspective, I undertook to think about its fabrication; which I finally found, and so perfectly that one which I made far surpassed the reputation of the Flemish one...”

Galileo’s letter of 29 VIII 1609 to his brother-in-law, Landucci

”And word having reached Venice that I had made one, it is six days since I was called by the Signoria, to which I had to show it together with the entire Senate, to the infinite amazement of all; and there have been numerous gentlemen and senators, who, though old, have more than once scaled the stairs of the highest campaniles in Venice to observe at sea sails and vessels so far away that, coming under full sail to port, two hours or more were required before they could be seen without my spy-glass. For in fact the effect of this instrument is to represent an object that is, for example, fifty miles away, as large and near as if it were only five.”

Galileo’s letter of 29 VIII 1609 to his brother-in-law, Benedetto Landucci

SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRO..OMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS IN-
NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeri-
tate mirabili circumuoluti.; quos, nemini in hanc vsque
diem cognitos, nouissimè Author depræ-
hendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

STARRY MESSENGER
revealing great and very wonderful
sights and displaying to the gaze of
everyone, but especially philosophers
and astronomers, the things that were
observed by GALILEO GALILEI,
Florentine patrician and public
mathematician of the University
of Padua, with the help of a spyglass
lately devised by him, about the face
of the Moon, countless fixed stars,
the Milky Way, nebulous stars,
but especially about four planets swiftly
revolving around Jupiter at differing
intervals and periods and known to
no one before the Author recently
detected them and decided that
they should be named
MEDICEAN STARS

SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRO..OMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt observata in LVNÆ FACIE, FIXIS INNVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeritate mirabili circumuoluti.; quos, nemini in hanc vsque diem cognitos, nouissimè Author deprehendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.

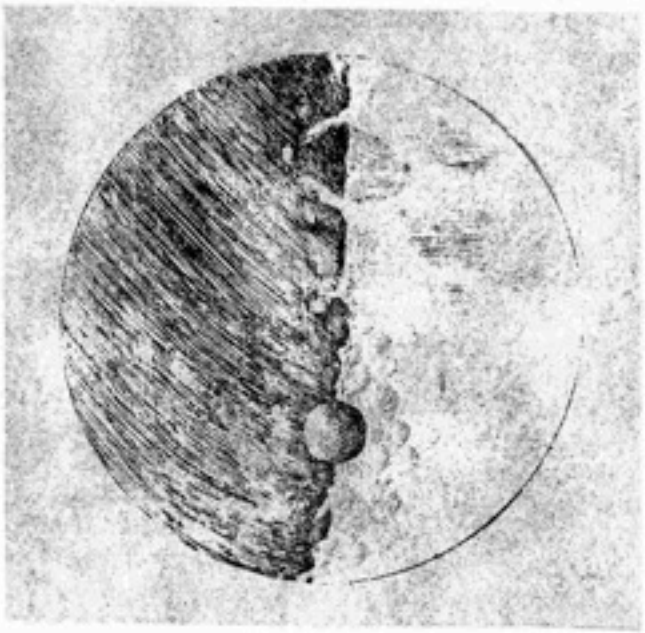
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

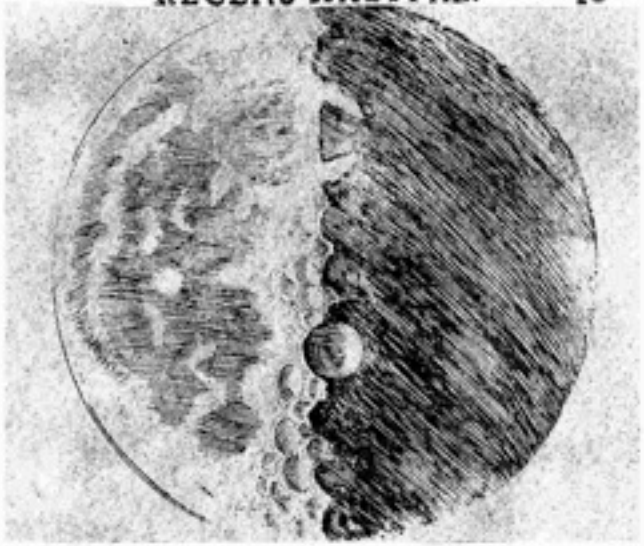
SIDEREVS,
NVNCIVS
MAGNA, LONGEQVE ADMIRA-
bilia Spectacula pandens, suspiciendaq; pro-
ponens vnicuiq;, præsertim vero
PHILOSOPHIS, atq; ASTRONOMIS, quæ
GALILEO GALILEO PA-
TRITIO FLORENTINO
Patanini Gymnasii Publico
Mathematico
PERSPICILLI
Nuper a se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS INNVMERIS, LACTEO CIRCVLO STELLIS NEBVLOSIS,
Apprime vero in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atq; periodis, celeritate mirabili circumuolutis; quos, nemini in hanc vsq; diem cognitos, nouissime Auctor deprehendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.

M. D.  C. X

Prostat Francofurti in Palatio Patheniano.

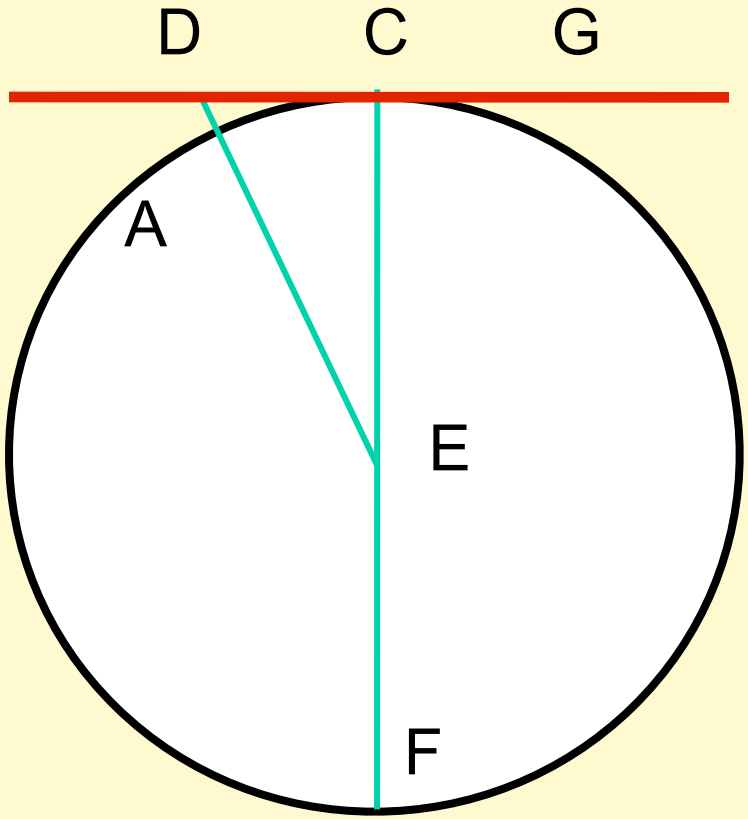
ctum daturam. Depreſſiores inſuper in Luna cernuntur magnæ maculæ, quàm clariores plagæ; in illa enim tam creſcente, quam decreſcente ſemper in lucis tenebrarumque confinio, prominente hincindè circa ipſas magnas maculas contermini partis lucidioris; veluti in deſcribendis figuris obſeruauimus; neque depreſſiores tantummodo ſunt dictarum macularum termini, ſed æquabiliores, nec rugis, aut aſperitatibus interrupti. Lucidior vero pars maximè propè maculas eminet; adeò vt, & ante quadraturam primam, & in ipſa fermè ſecunda circa maculam quandam, ſuperiorem, borealem nempè Lune plagam occupantem valdè attollantur tam ſupra illam, quàm infra ingentes quædam eminentiæ, veluti appoſitæ præſeferunt delineationes.





Hæc eadem macula ante ſecundam quadraturam nigrioribus quibuſdam terminis circumuallata compicitur; qui tanquam altiſſima montium iuga ex parte Soli auerſa obſcuriores apparent, quà verò Solem reſpiciunt lucidiores extant; cuius oppoſitum in cauitatibus accidit, quarum pars Soli auerſa ſplendens apparet, obſcura verò, ac vmbroſa, quæ ex parte Solis ſita eſt. Imminuta deinde luminoſa ſuperficie, cum primum tota fermè dicta macula tenebris eſt obducta, clariora mõtium dorſa eminenter tenebras ſcandunt. Hanc duplicem apparentiam ſequentes figuræ commoſtrant.

Galileo's drawings of the moon (1610)



Measurement of the height of lunar mountains

***Sidereus nuncius* (1610)**

cœtum offendes. Amplius (quod magis mirabilis) Stellæ ab Astronomis singulis in hanc vsque diē NEBVLOSAE appellatæ, Stellularum mirum immodum consitarum greges sunt; ex quarum radiorum commixtione, dum vnaqueque ob exilitatem, seu maximam à nobis remotionem, oculorum aciem fugit, candor ille consurgit, qui densior pars cœli, Stellarum, aut Solis radios retorquere valens, hucusque creditus est. Nos ex illis nonnullas obseruauimus; & duarum Asterismos subnectere voluimus.

In primo habes NEBVLOSAM Capitis Orionis appellatam, in qua Stellas vigintivnas numerauimus.

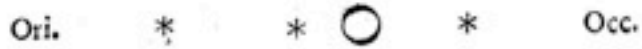
Secundus NEBVLOSAM PRAESEPE nuncupatam continet, quæ non vna tantū Stella est, sed congeries Stellularum plurium quam quadraginta: nos præter Asellos trigintasex notauimus in hunc, qui sequitur ordinem dispositas.

NEBVLOSA ORIONIS.

NEBVLOSA PRAESEPE.

De Luna, de inerrantibus Stellis, ac de Galaxya, quæ hactenus obseruata sunt breuiter enarrauimus. Superest vt, quod maximum in præsenti negotio existimandum videtur, quatuor PLANETAS à primo mundi exordio ad nostra vsque tempora nunquam conspectos, occasionem reperiendi, atque obseruandi, nec non ipsorum loca, atque per duos proximè menses obseruationes circa eorundem lationes, ac mutationes habitas, aperiamus, ac promulgemus: astronomos omnes conuocantes, vt ad illorum periodos inquirendas, atq; definiendas se conferant, quod nobis in hanc vsque diem ob temporis angustiam assequi minime licuit. Illos tamen iterum monitos facimus, ne ad talem inspectionem incassum accedant, Perspicillo exactissimo opus esse, & quale in principio sermonis huius, descripsimus.

Die itaque septima Ianuarij instantis anni millesimi sexcentesimi decimi, hora sequentis noctis prima, cum cœlestia sydera per Perspicillum spectarem, Iuppiter se se obuiam fecit, cumque admodum excellens mihi parassem instrumentum, (quod antea ob alterius Organi debilitatem minime contigerat) tres illi adstare stellulas, exiguas quidem, veruntamen clarissimas, cognoui; quæ licet è numero inerrantium à me crederentur, non nullam tamen intulerunt admirationem, eo quod secundum exactam lineam rectam, atque Eclypticæ pararellam dispositæ videbantur: ac cæteris magnitudine paribus splendidiores: eratque illarum inter se & ad Iouem talis constitutio.



E ex parte,

Pages from Galileo's *Sidereus nuncius* (1610)

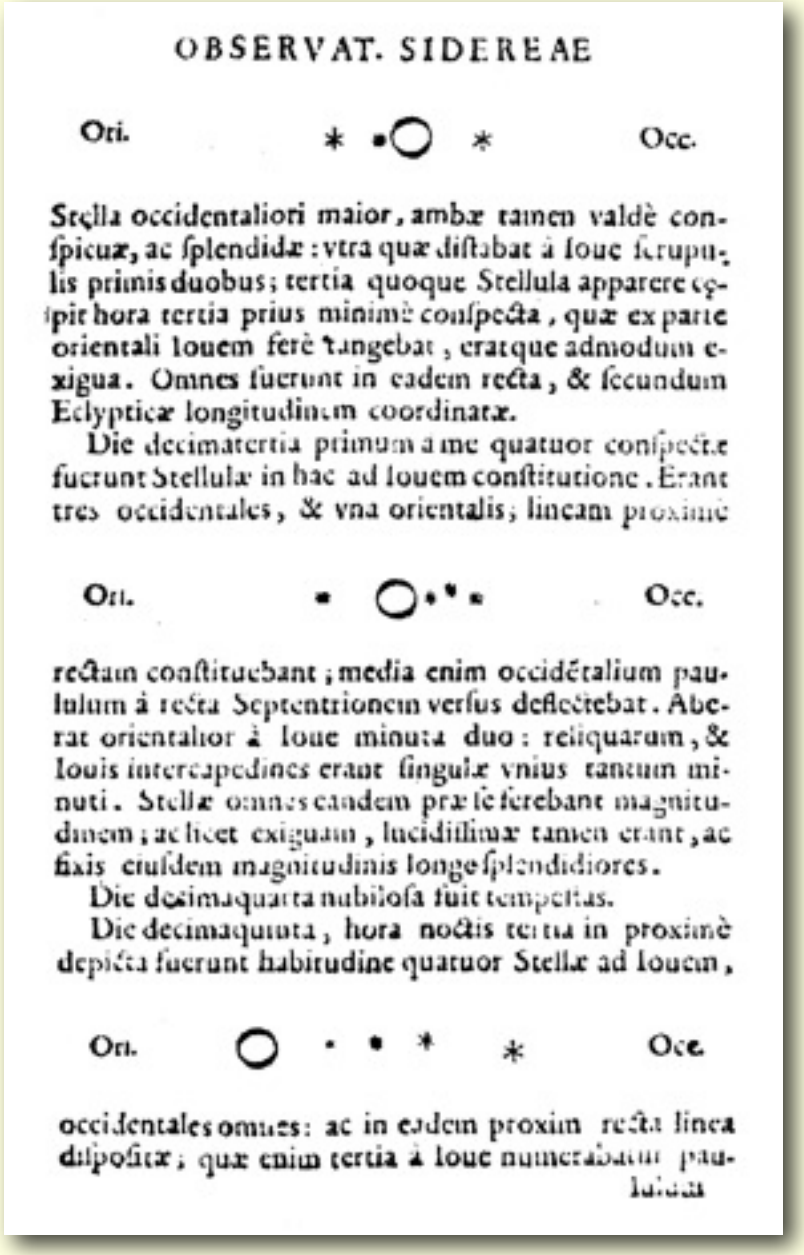
Discovery of the ”Medicean Stars” (from *Sidereus nuncius*)

”I have now finished my brief account of the observations which I have thus far made with regard to the moon, the fixed stars, and the Milky Way. There remains the matter, which seems to me to deserve to be considered the most important in this work, namely, that I should disclose and publish to the world the occasion of discovering and observing four PLANETS, never seen from the very beginning of the world up to our own times, their positions, and the observations made during the last two months about their movements and their changes of magnitude...”

Discovery of the ”Medicean Stars” (from *Sidereus nuncius*)

”On the 7th day of January in the present year, 1610, at the first hour of the night, when I was viewing the heavenly bodies with a telescope, Jupiter presented itself to me; and because I had prepared for myself a very excellent instrument, I perceived (as I had not before, on account of the weakness of my previous instrument) that beside the planet there were three little stars, small but very bright. Though I believed them to belong to the number of the fixed stars, yet they made me somewhat wonder, because they seemed to be arranged exactly in a straight line, parallel to the ecliptic, and to be brighter than the rest of the stars, equal to them in magnitude. Their position with reference to one another and to Jupiter was as follows:

On the east side there were two stars, and a single one towards the west. The star which was furthest towards the east, and the western star, appeared larger than the third. I paid no attention to the distances between them and Jupiter, for, as I have already said, at first I believed them to be fixed stars. But when on January 8th, led by what, I do not know, I turned again to look at the same part of the heavens, I found a very different state of things...”



OBSERVAT. SIDEREAE

Ori. * ●○ * Occ.

Stella occidentaliori maior, ambæ tamen valdè conſpicuæ, ac ſplendidæ: vtra quæ diſtabat à Ioue ſcrupulis primis duobus; tertia quoque Stellula apparere cœpit hora tertia prius minimè conſpecta, quæ ex parte orientali Iouem ferè tangebat, eratque admodum exigua. Omnes fuerunt in eadem recta, & ſecundum Eclypticæ longitudinem coordinatæ.

Die decimatertia primum a me quatuor conſpectæ fuerunt Stellulæ in hac ad Iouem conſtitutione. Erant tres occidentales, & vna orientalis; lineam proximè

Ori. ● ○ ● ● Occ.

rectam conſtituebant; media enim occidentalium paululum à recta Septentrionem verſus deflectebat. Aberat orientalior à Ioue minuta duo: reliquarum, & Iouis intercapedines erant ſingulæ vnius tantum minuti. Stellæ omnes eandem præ ſe ferebant magnitudinem; ac licet exiguam, lucidiſſimæ tamen erant, ac fixis eiuſdem magnitudinis longe ſplendidiores.

Die decimaquarta nubiloſa fuit tempeſtas.

Die decimaquinta, hora noctis tertia in proximè depicta fuerunt habitudine quatuor Stellæ ad Iouem,

Ori. ○ • • * * Occ.

occidentales omnes: ac in eadem proxim recta linea diſpoſitæ; quæ enim tertia à Ioue numerabatur paululum

In the *Sidereus nuncius* Galileo published his observations of the four Jupiter's satellites performed every night free from clouds. The last observation was registered on March 2, and the book was published in Venice on March 12.

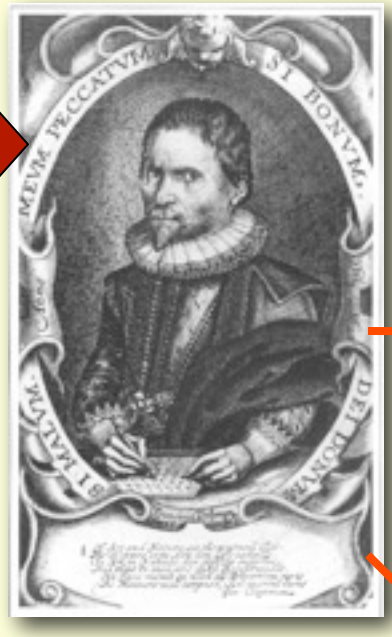
”Now touching the occurrents of the present, I send herewith unto His Majesty the strangest piece of news (as I may justly call it) that he hath ever yet received from any part of the world; which is the annexed book (come abroad this very day) of the Mathematical Professor at Padua, who by the help of an optical instrument (which both enlargeth and approximateth the object) invented first in Flanders, and bettered by himself, hath discovered four new planets rolling about the sphere of Jupiter, besides many other unknown stars; likewise, the true cause of the Via Lactea, so long searched; and lastly, that the moon is not spherical, but endued with many prominences, and, which is of all the strangest, illuminated with the solar light by reflection from the body of the earth, as he seemeth to say. So as upon the whole subject he hath first overthrown all former astronomy - for we must have a new sphere to save the appearances - and next all astrology. For the virtue of these new planets must needs vary the judicial part, and why may there not yet be more? These things I have been bold thus to discourse unto your Lordship, whereof here all corners are full. And the author runneth a fortune to be either exceeding famous or exceeding ridiculous. By the next ship your Lordship shall receive from me one of the above instruments, as it is bettered by this man.”

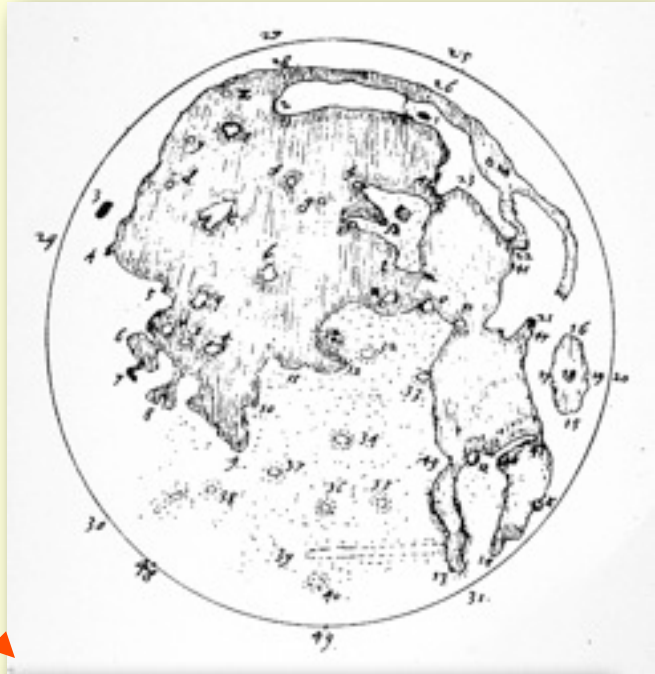
Letter of Sir Henry Wotton, the British Ambassador to Venice, March 13, 1610

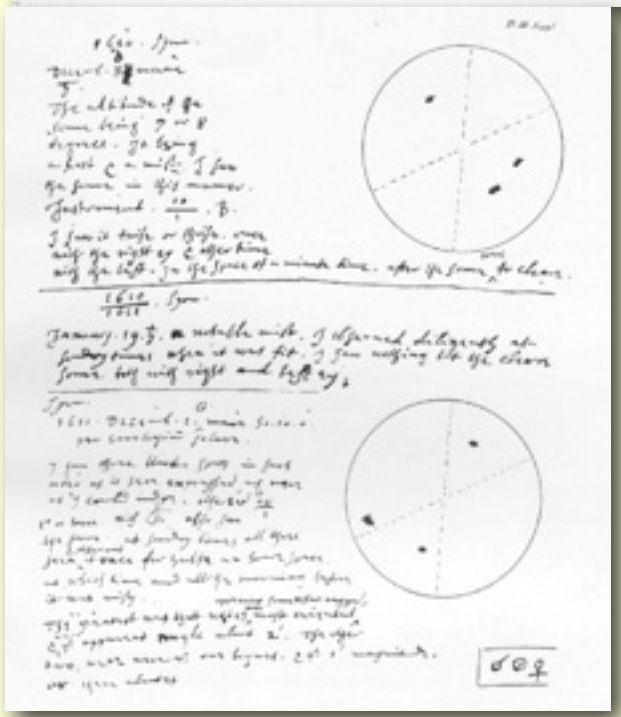
In England **Thomas Harriot** made drawings of moon's surface based on observations with his telescope already in July, 1609. He later saw sunspots and the satellites of Jupiter but did not publish anything on these subjects.

The four satellites of Jupiter were discovered independently by **Simon Mayr** in Germany, but he published the results later than Galileo.

Thus Galileo's fame was earned justly.







IOANNIS KEPLERI
Mathematici Cæsarei

DISSERTATIO

Cum

NVNCIO SIDEREO
nuper ad mortales missso

GALILÆO GALILÆO
Mathematico Patavino.

Alcinous
Δεῖ δ' ἐλευθέριον εἶναι τὴν γνώμην τὸ μέλλον τὰ φιλοσοφοῦν.

Huic acceßit Phænomenon ſingulare de Mercurio ab eodem Keplero in Sole deprehenſo.

Florentiæ, Apud Io. Antonium Canęum.
Superiorum permiſſu. 1610.

IOANNIS KEPLERI S.
Cæſ. Maieſt. Mathematici.

NARRATIO

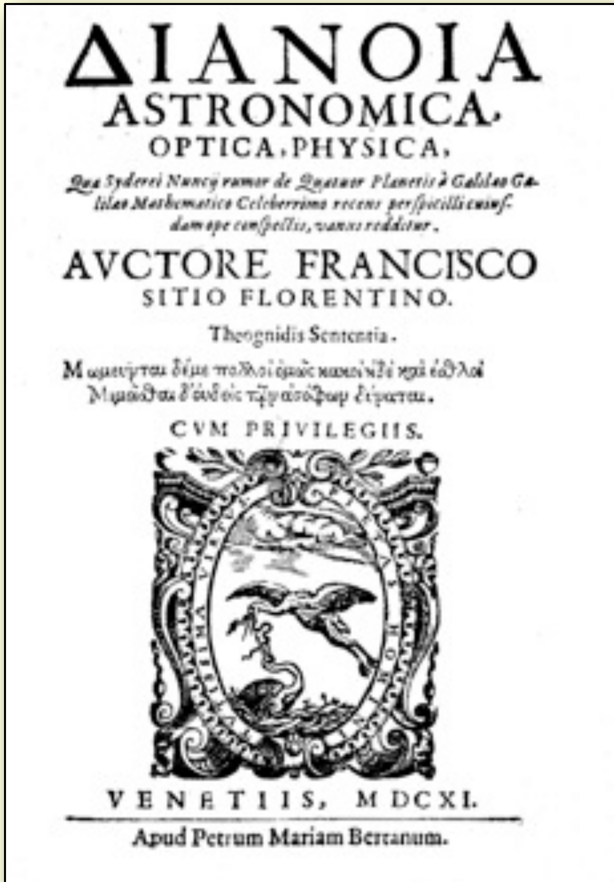
DE OBSERVATIS A SE
quatuor Iouis ſatellitibus erronibus,

QVOS GALILAEVS GALILAEVS Mathematicus Florentinus iure inuentionis MEDICEA ſidera nuncupauit.

CVM ADIVNCTA DISSERTATIONE DE Nuncio ſidereo nuper ad mortales miſſo.

FLORENTIAE.
Apud Coſmum Iunctam. 1611.

Francesco Sizi


ΔΙΑΝΟΙΑ
ASTRONOMICA.
OPTICA, PHYSICA,
Qua Syderei Nuncij rumor de Quatuor Planetis à Galilaeo Galilaeo Mathematico Celeberrimo recens perspicilli cuiusdam ope conspectis, vanus redditur.
AVCTORE FRANCISCO
SITIO FLORENTINO.
Theognidis Sententia.
[illegible]
[illegible]
CVM PRIVILEGIIS.
VENETIIS, MDCXI.
Apud Petrum Mariam Bertanum.

"There are seven windows in the head, two nostrils, two ears, two eyes and a mouth; so in the heavens there are two favourable stars, two unpropitious, two luminaries, and Mercury alone undecided and indifferent. From which and many other similar phenomena of nature such as the seven metals, etc., which is more tedious to enumerate, we gather that the number of planets is necessarily seven.... Besides, the Jews and other ancient nations, as well as modern Europeans, have adopted the division of the week into seven days, and have named them from the seven planets; now if we increase the number of planets, this whole system falls to the ground... Moreover, the satellites are invisible to the naked eye and therefore can have no influence on the earth and therefore would be useless and therefore do not exist."

ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI

COMPRESE IN TRE LETTERE SCRITTE

ALL'ILLVSTRISSIMO SIGNOR

MARCO VELSERI LINCEO

DVVMVIRO D'AVGVSTA

CONSIGLIERO DI SVA MAESTA CESAREA

DAL SIGNOR

GALILEO GALILEI LINCEO

Nobil Fiorentino, Filosofo e Matematico Primario del Serenis.
D. COSIMO II. GRAN DVCA DI TOSCANA.

Si aggiungono nel fine le Lettere, e Disquisitioni del finto Apelle.

IN ROMA, Appresso Giacomo Mascardi. MDCXIII.

CON LICENZA DE' SVPERIORI.

”Philosophy is written in that grand book –
I mean the universe – which stands forever open before our eyes; but it cannot be read until we have learnt to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly impossible to comprehend a single word of it; without these, one is wandering about in a dark labyrinth.”

Galileo, *Il Saggiatore*

DIALOGO
DI
GALILEO GALILEI LINCEO
MATEMATICO SOPRAORDINARIO
DELLO STVDIO DI PISA.
E Filosofo, e Matematico primario del
SERENISSIMO
GR. DVCA DI TOSCANA.

Doue ne i congressi di quattro giornate si discorre sopra i due

MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO;

Proponendo indeterminatamente le ragioni Filosofiche, e Naturali tanto per l'vna, quanto per l'altra parte.

CON PRI VILEGI.

IN FIORENZA, Per Gio: Batista Landini MDCXXXII.

CON LICENZA DE' SVPERIORI.

Imprimatur si videbitur Reuerendiss. P. Magisto S Palatij Apostolici.
A. Episcopus Bellicastensis Vicesgerens.

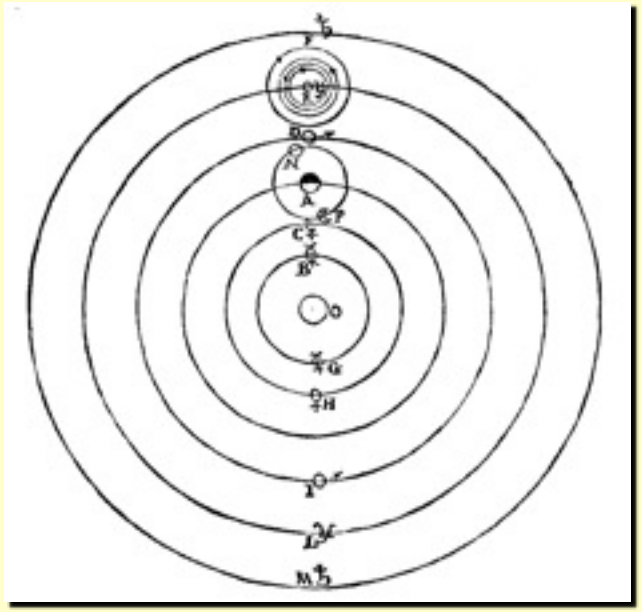
Imprimatur
Fr. Nicolaus Riccardius
Sacri Palatij Apostolici Magister.

Imprimatur Florentiæ ordinibus consuetis seruatis.
11. Septembris 1630.
Petrus Nicolinus Vic. Gener. Florentiæ.

Imprimatur die 11. Septembris 1630.
Fr. Clemens Egidius Inqu. Gener. Florentiæ.

Stampisi adi 12. di Settembre 1630.
Niccolo dell' Altella.

Galileo's *Dialogue*, Third Day



"There remains what seemed to be a great difficulty with the earth's movement; that is, unlike all the other planets that revolve around the sun, it alone does so (in one year) accompanied by the moon together with the whole elemental sphere, while the same moon moves every month around the earth. Here we must, once again, proclaim and exalt the admirable perspicacity of Copernicus and at the same time pity his misfortune; for he does not live in our time when, to remove the apparent absurdity of the shared motion of the earth and moon, we can see that Jupiter (being almost another earth) goes around the sun in twelve years accompanied not by one moon but by four moons, together with all that may be contained within the orbs of the four Medicean stars."

The trial of Galileo

1614 XII	First denunciation of Galileo
1616 25 II	Galileo meets Bellarmino
1616 5 III	Condemnation of Copernicanism
1623	Publication of *Il Saggiatore*
?	Another denunciation of Galileo
1632 21 II	Publication of *Dialogo* with necessary *Imprimatur*
1632 23 XI	Galileo summoned to Rome
1633 12 IV	First session of the tribunal; Galileo presented the document concerning the meeting of 25 II 1616; he was shown the document of 26 II 1616 (fabricated?)
1633 27 IV	Mysterious meeting of Galileo with Vincenzo Firenzuola
1633 30 IV	Resumption of the trial, Galileo pleaded guilty
1633 22 VI	Sentence (signed by only 7 of 10 judges)
1642 8 I	Death of Galileo (under house arrest)
1992 31 X	Pope John Paul II rehabilitated Galileo in the speech to the Pontifical Academy of Sciences

DECRETVM

Sacræ Cõgregationis Illuſtriſſimorum S. R. E. Cardinalium, à S. D. PAVLO Papa V. Sanctaque Sede Apoſtolica ad Indicem Librorum, eorundemq; permiſſionem, prohibitionem, expurgationem, & impreſſionem, in vniuerſa Republica Chriſtiana ſpecialiter deputatorum, vbique publicandum.

EDICTA.

Et quia etiam ad notitiam præfatæ Sacræ Congregationis peruenit, falſam illam doctrinam Pithagoricam, diuinæq; ſcripturæ omnino aduerſantem, de mobilitate Terræ, & immobilitate Solis, quam Nicolaus Copernicus de reuolutionibus orbiũ cœleſtium, & Didacus Aſtunica in Iob etiam docent, iam diuulgari & à multis recipi; ſicuti videre eſt ex quadam epiſtola impreſſa cuiuſdam Patris Carmelitæ, cui titulus, Lettera del R. Padre Maeſtro Paolo Antonio Foſcarini Carmelitano, ſopra l' opinione de Pittagorici, e del Copernico, della mobilita della Terra, e ſtabilita del Sole, & il nuouo Pittagorico Siſtema del Mondo, in Napoli per Lazzaro Scoriggio 1615. in qua dictus Pater oſtendere conatur, præfatam doctrinam de immobilitate Solis in centro Mundi, & mobilitate Terræ, conſonam eſſe veritati, & non aduerſari Sacræ Scripturæ: Ideo nè vlteriùs huiuſmodi opinio in perniciem Catholicæ veritatis ſerpat, cenſuit dictos Nicolaum Copernicum de reuolutionibus orbium, & Didacũ Aſtunica in Iob, ſuſpendendos eſſe donec corrigantur. Librum verò Patris Pauli Antonij Foſcarini Carmelitæ omnino prohibendum, atque damnandum; alioſq; omnes Libros pariter

CONGREG: CARDINAL.

riter idem docentes prohibendos, prout præſenti Decreto omnes reſpectiue prohibet, damnat, atq; ſuſpendit. In quorum fidem præſens Decretum manu, & ſigillo Illuſtriſſimi & Reuerendiſſimi D. Cardinalis S. Cæciliæ Epiſcopi Albanen ſignatum, & munitum fuit die 5. Martij 1616.

P. Epiſc. Albanen. Card. S Cæciliæ.

Regiſtr. fol. 90.

Locus + Sigilli.

F. Franciſcus Magdalenus Capiferreus Ord: Prædic. Secret.

Decretum Sacrae Congregationis Illustrissimorum S. R. E. Cardinalium... ad Indicem Librorum... deputatorum, die 5 Martii 1616.

"...This Holy Congregation has also learned about the spreading and acceptance by many of the false Pythagorean doctrine, altogether contrary to the Holy Scripture, that the earth moves and the sun is motionless, which is also taught by Nicolaus Copernicus's *On the Revolutions of the Heavenly Spheres* and by Diego de Zuñiga's *On Job*...

Therefore, in order that this opinion may not creep any further to the prejudice of Catholic truth, the Congregation has decided that the books by Nicolaus Copernicus (*On the Revolutions of Spheres)* and Diego de Zuñiga (*On Job)* be suspended until corrected; ...and that all other books which teach the same be likewise prohibited, according to whether with the present decree it prohibits, condemns, and suspends them respectively. In witness thereof, this decree has been signed by the hand and stamped with the seal of the Most Illustrious and Reverend Lord Cardinal of St. Cecilia, Bishop of Albano, on 5 March 1616.."

Excerpts from the sentence in the trial of Galileo

”Whereas you, Galileo, son of the late Vincenzio Galilei, Florentine, aged seventy years, were denounced to this Holy Office in 1615 for holding as true the false doctrine taught by some that the sun is the centre of the world and motionless and the earth moves even with diurnal motion; for having disciples to whom you taught the same doctrine; for being in correspondence with some German mathematicians about it; for having published some letters entitled *On Sunspots,* in which you explained the same doctrine as true; for interpreting Holy Scripture according to your own meaning in response to objections based on Scripture which were sometimes made to you; and whereas later we received a copy of an essay in the form of a letter, which was said to have been written by you to a former disciple of yours and which in accordance with Copernicus's position contains various propositions against the authority and true meaning of Holy Scripture;”

Excerpts from the sentence in the trial of Galileo

”And whereas this Holy Tribunal wanted to remedy the disorder and the harm which derived from it and which was growing to the detriment of the Holy Faith, by order of His Holiness and the Most Eminent and Most Reverend Lord Cardinals of this Supreme and Universal Inquisition, the Assessor Theologians assessed the two propositions of the sun's stability and the earth's motion as follows:
That the sun is the centre of the world and motionless is a proposition which is philosophically absurd and false, and formally heretical, for being explicitly contrary to Holy Scripture;
That the earth is neither the centre of the world nor motionless but moves even with diurnal motion is philosophically equally absurd and false, and theologically at least erroneous in the Faith...”

Excerpts from the sentence in the trial of Galileo

”And whereas a book has appeared here lately, printed in Florence last year, whose inscription showed that you were the author, the title being *Dialogue by Galileo Galilei on the two Chief World Systems, Ptolemaic and Copernican;* and whereas the Holy Congregation was informed that with the printing of this book the false opinion of the earth's motion and sun's stability was being disseminated and taking hold more and more every day, the said book was diligently examined and found to violate explicitly the above-mentioned injunction given to you; for in the same book you have defended the said opinion already condemned and so declared to your face, although in the said book you try by means of various subterfuges to give the impression of leaving it undecided and labeled as probable; this is still a very serious error since there is no way an opinion declared and defined contrary to divine Scripture may be probable...”

Excerpts from the sentence in the trial of Galileo

”Therefore, by our order you were summoned to this Holy Office, where, examined under oath, you acknowledged the book as written and published by you. You confessed that about ten or twelve years ago, after having been given the injunction mentioned above, you began writing the said book, and that then you asked for permission to print it without explaining to those who gave you such permission that you were under the injunction of not holding, defending, or teaching such a doctrine in any way whatever.”

Excerpts from the sentence in the trial of Galileo

”...We say, pronounce, sentence, and declare that you, the above-mentioned Galileo, because of the things deduced in the trial and confessed by you as above, have rendered yourself according to this Holy Office vehemently suspected of heresy, namely of having held and believed a doctrine which is false and contrary to the divine and Holy Scripture: that the sun is the centre of the world and does not move from east to west, and the earth moves and is not the centre of the world, and that one may hold and defend as probable an opinion after it has been declared and defined contrary to Holy Scripture.”

Excerpts from the sentence in the trial of Galileo

”Consequently you have incurred all the censures and penalties imposed and promulgated by the sacred canons and all particular and general laws against such delinquents. We are willing to absolve you from them provided that first, with a sincere heart and unfeigned faith, in front of us you abjure, curse, and detest the above-mentioned errors and heresies, and every other error and heresy contrary to the Catholic and Apostolic Church, in the manner and form we will prescribe to you. .”

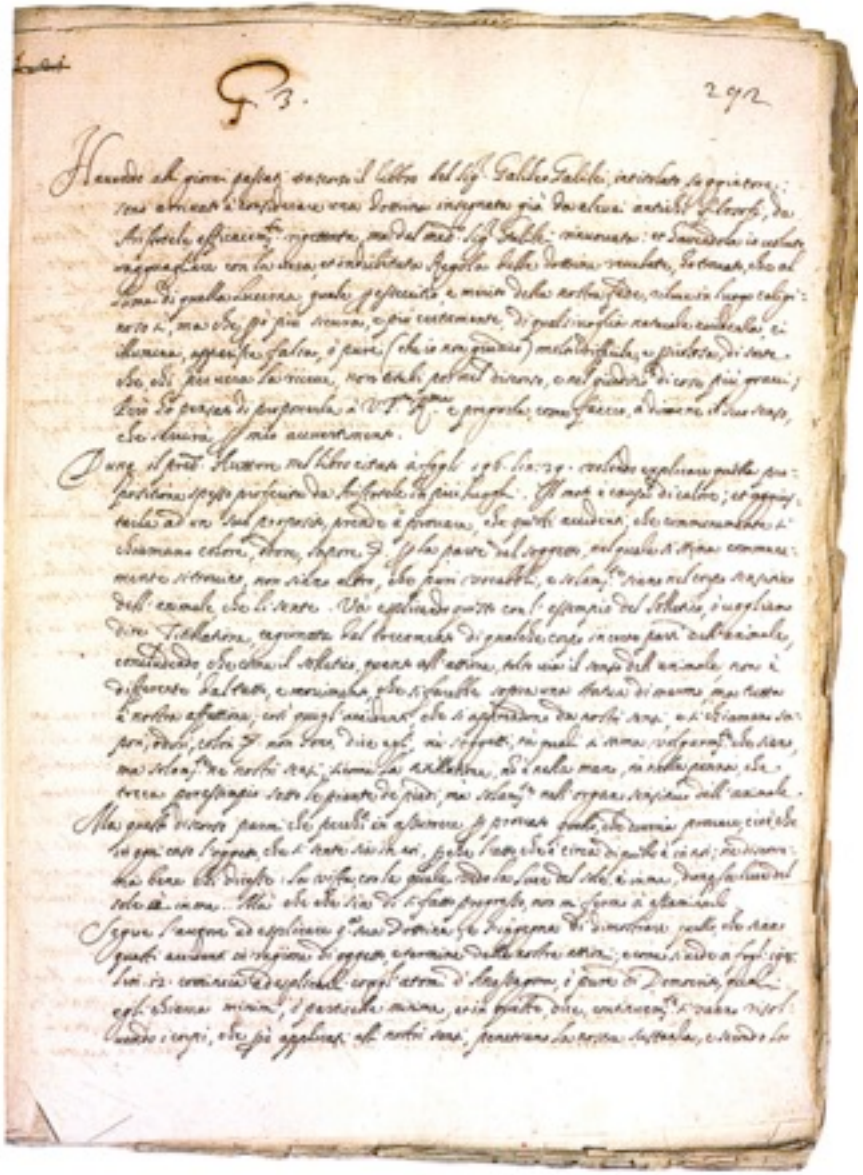
Excerpts from the sentence in the trial of Galileo

„Furthermore, so that this serious and pernicious error and transgression of yours does not remain completely unpunished, and so that you will be more cautious in the future and an example for others to abstain from similar crimes, we order that the book *Dialogue* by Galileo Galilei be prohibited by public edict.
We condemn you to formal imprisonment in this Holy Office at our pleasure. As a salutary penance we impose on you to recite the seven penitential Psalms once a week for the next three years. And we reserve the authority to moderate, change, or condone wholly or in part the above-mentioned penalties and penances..”

Three out of ten judges, cardinals Gasparo Borgia, Francesco Barberini, and Laudivio Zacchia did not sign the sentence

”If Galileo had known how to retain the affection of the Fathers of this College, he would have lived gloriously before the world, and none of his misfortunes would have happened, and he would have been able to write as he chose about everything, including the motion of the earth...”

Father Grienberger,
professor of astronomy at the Collegio Romano



Anonymous denunciation that Galileo propagated false and dangerous atomistic ideas in *Il Saggiatore*

”Having in past days perused Signor Galileo Galilei's book entitled *The Assayer* I have come to consider a doctrine already taught by certain ancient philosophers and effectively rejected by Aristotle, but renewed by the same Signor Galilei. And having decided to compare it with the true and undoubted Rule of revealed doctrines, I have found that in the Light of that Lantern which by the exercise and merit of our faith shines out indeed in murky places, and which more securely and more certainly than any natural evidence illuminates us, this doctrine appears false, or even (which I do not judge) very difficult and dangerous... Therefore, the aforesaid Author, in the book cited (on page 196, line 29), wishing to explain that proposition proffered by Aristotle in so many places - that motion is the cause of heat - and to adjust it to his intention, sets out to prove that these accidents which are commonly called colours, odours, tastes, etc., on the part of the subject, in which it is commonly believed that they are found, are nothing but pure words and are only in the sensitive body of the animal dial feels them...

”…Now if one admits this philosophy of accidents as true, it seems to me, that makes greatly difficult the existence of the accidents of the bread and wine which in the Most Holy Sacrament are separated from their substance; since finding again therein the terms, and the objects of touch, sight, taste, etc., one will also have to say according to this doctrine that there are the very tiny particles with which the substance of the bread first moved our senses, which if they were substantial (as Anaxagoras said, and this author seems to allow on page 200, line 28), it follows that in the Sacrament there are substantial parts of bread or wine, which is the error condemned by the Sacred Tridentine Council, Session 13, Canon 2.”

”Or actually, if they were only sizes, shapes, numbers, etc., as he also seems clearly to admit, agreeing with Democritus, it follows that all these are accidental modes, or, as others say, shapes of quantity. While the Sacred Councils, and especially the Trident Council in the passage cited, determine that after the Consecration there remain in the Sacrament only the Accidents of the bread and wine, he instead says that there only remains the quantity with triangular shapes, acute or obtuse, etc., and that with these accidents alone is saved the existence of accidents or sensible species - which consequence seems to me not only in conflict with the entire communion of Theologians who teach us that in the Sacrament remain all the sensible accidents of bread, wine, colour, smell, and taste, and not mere words, but also, as is known, with the good judgment that the quantity of the substance does not remain. Again, this is inevitably repugnant to the truth of the Sacred Councils...”

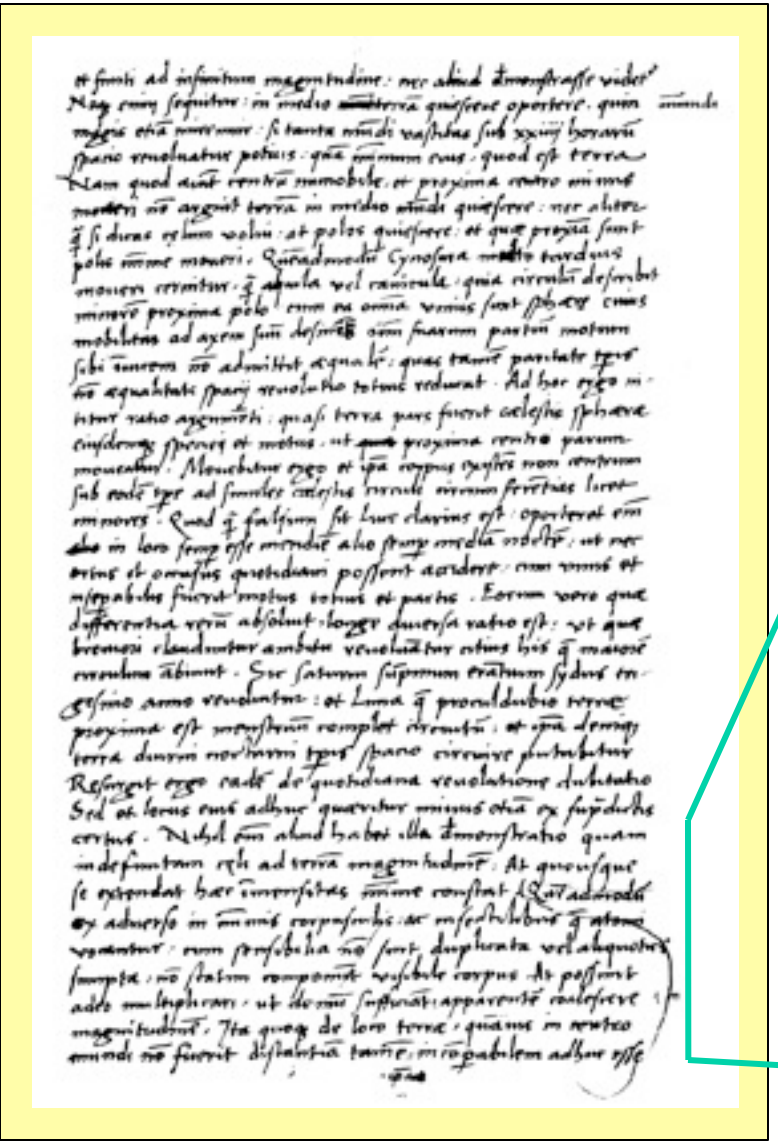
(from the book *Galileo Heretic* by Redondi)

”I think that tastes, odours, colours, and so forth are no more than mere names so far as it pertains to the subject wherein they reside, and that they have their habitation only in the sensorium. Thus if the living creature were removed, all those qualities would be removed and annihilated. Yet since we have imposed upon them particular names which differ from the names of those other previous real attributes, we wish to believe that they should also be truly and really different from the latter...
I do not believe that for exciting in us tastes, odours, and sounds there are required in external bodies anything but sizes, shapes, numbers, and slow or fast movements, and I think that if ears, tongues, and noses were taken away, shapes and numbers and motions would remain but not odours or tastes or sounds. These, I believe, are nothing but names...”

Galileo, *Il Saggiatore*

Episodes of fight against atomistic ideas

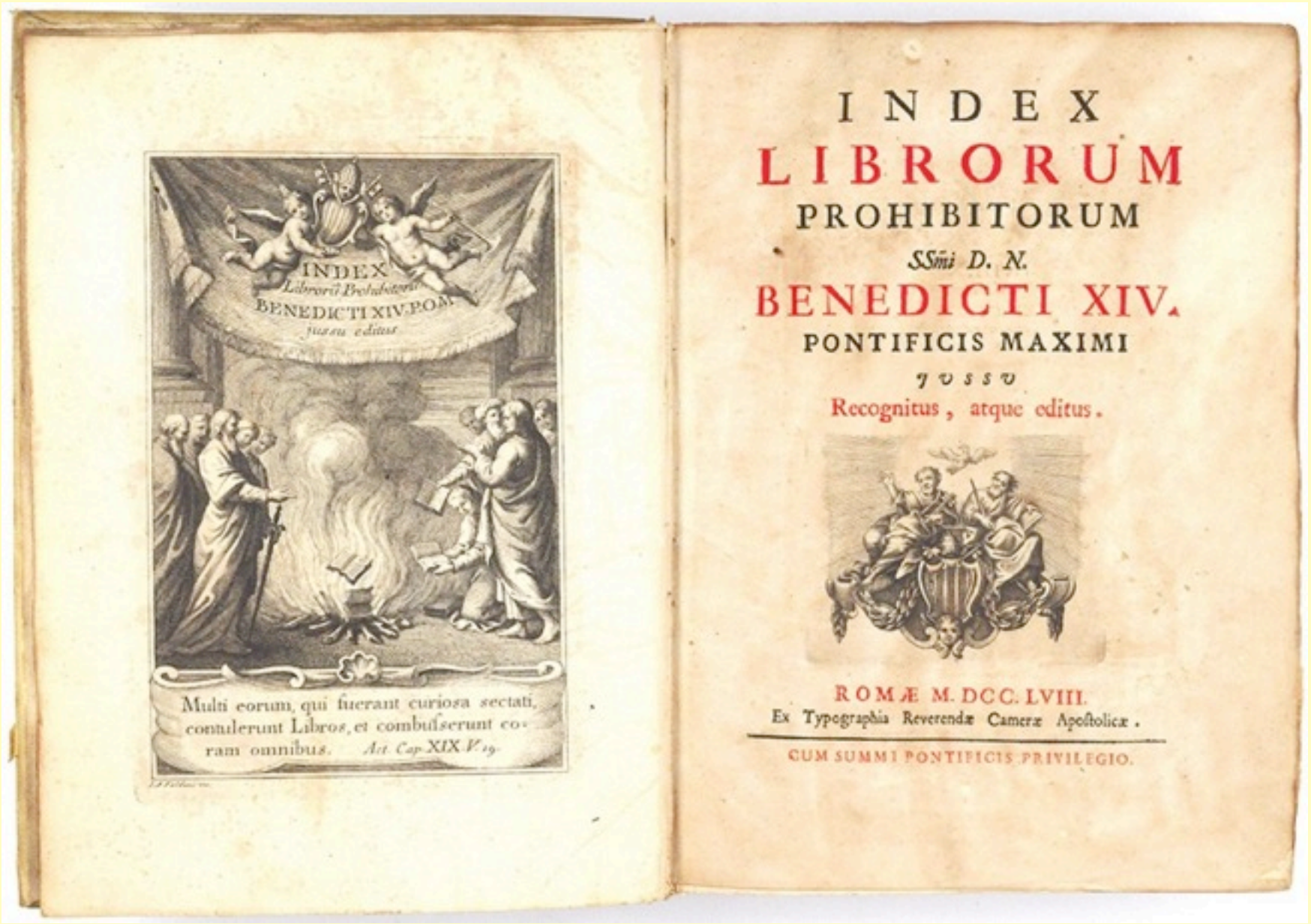
1347, 25 XI	Nicolas of Autrecourt forced to publicly burn in Paris his books on atoms
1543	A short passage on atoms in *De revolutionibus*, erased by censors, did not appear in the printed book
1551	The Council of Trent proclaimed the dogma of Eucharist
1624, 23 VIII	In Paris Jean Bitaud, Antoine de Villon and Etienne de Clave announced a public defense of the thesis that „*omnia componi ex Atomis et indivisibles*". One of the organizers was arrested, and the debate forbidden. It was declared that further attempts of discussion on similar topics will be punished by death.
1633, 22 VI	Galileo sentenced to prison – formally for teaching heliocentrism, but possibly for propagating atomistic ideas
1691	Grand Duke of Tuscany Cosimo III: „No professor of the University of Pisa may read or teach, either publicly or privately, whether in writing or by speech, the Democritan philosophy, namely about atoms, but only the Aristotelian, and whoever should in any way transgress the wish of the Grand Duke may consider himself dismissed."



”But its position is also still to be sought for, and is even less certain from what has been said above. For that proof has no other consequence than the indefinite size of the heaven compared with the earth. But it is far from settled how far this immensity extends. As conversely occurs in the smallest and inseparable corpuscles (*minimis corpusculis ac insectibilibus*), which are called atoms, not being perceptible [even if] duplicated or multiplied several times, they do not immediately form a visible body, but can be multiplied until at last they are sufficient to come together in a size that can be seen. Thus, also on this place the earth, although it is not the centre of the world, its distance from the centre is not comparable in particular with the sphere of the fixed stars."
De revolutionibus, Book I, Chapter 6

A passage erased by censors did not appear in the printed book

Powerful weapon of the Inquisition



DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue ſcienze

Attenenti alla

MECANICA & i MOVIMENTI LOCALI;

del Signor

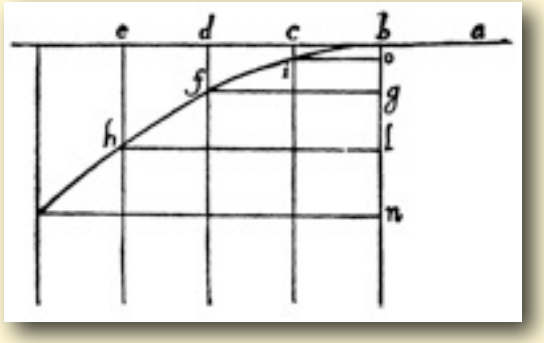
GALILEO GALILEI LINCEO,
Filoſofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.

Con vna Appendice del centro di grauità d'alcuni Solidi.

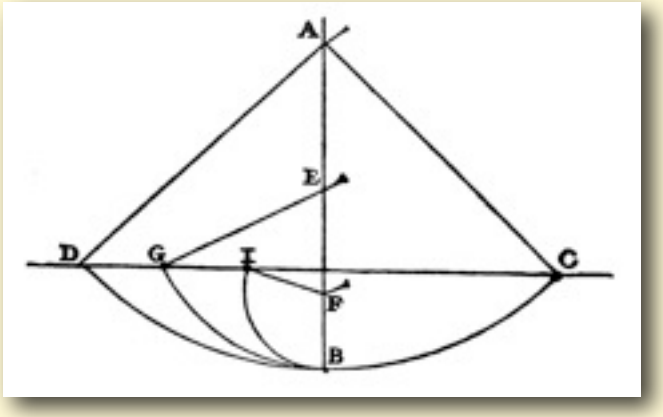
IN LEIDA,
Appreſſo gli Elſeuirii. M. D. C. XXXVIII.

Illustrations from the *Discorsi*

Considerations of the resistance of beams to fracture



Parabolic trajectory of a projectile thrown horizontally



Conservation of mechanical energy

Discorsi, First Day

Salviati: ...I greatly doubt that Aristotle ever tested by experiment whether it be true that two stones, one weighing ten times as much as the other, if allowed to fall, at the same instant, from a height of, say, 100 cubits, would so differ in speed that when the heavier had reached the ground, the other would not have fallen more than 10 cubits.
Simplicio: His language would seem to indicate that he had tried the experiment, because he says: We see the heavier; now the word see shows that he had made the experiment.
Sagredo: But I, Simplicio, who have made the test can assure you that a cannon ball weighing one or two hundred pounds, or even more, will not reach the ground by as much as a span ahead of a musket ball weighing only half a pound, provided both are dropped from a height of 200 cubits.
Salviati: But, even without further experiment, it is possible to prove clearly, by means of a short and conclusive argument, that a heavier body does not move more rapidly than a lighter one provided both bodies are of the same material and in short such as those mentioned by Aristotle. But tell me, Simplicio, whether you admit that each falling body acquires a definite speed fixed by nature, a velocity which cannot be increased or diminished except by the use of force [*violenza*] or resistance?

Discorsi, First Day (cont.)

Simplicio: There can be no doubt but that one and the same body moving in a single medium has a fixed velocity which is determined by nature and which cannot be increased except by the addition of momentum [*impeto*] or diminished except by some resistance which retards it.
Salviati: If then we take two bodies whose natural speeds are different, it is clear that on uniting the two, the more rapid one will be partly retarded by the slower, and the slower will be somewhat hastened by the swifter. Do you not agree with me in this opinion?
Simplicio: You are unquestionably right.
Salviati: But if this is true, and if a large stone moves with a speed of, say, eight while a smaller moves with a speed of four, then when they are united, the system will move with a speed less than eight; but the two stones when tied together make a stone larger than that which before moved with a speed of eight. Hence the heavier body moves with less speed than the lighter; an effect which is contrary to your supposition. Thus you see. how, from your assumption that the heavier body moves more rapidly than the lighter one, I infer that the heavier body moves more slowly.
Simplicio: I am all at sea because it appears to me that the smaller stone when added to the larger increases its weight and by adding weight I do not see how it can fail to increase its speed or, at least, not to diminish it.

Discorsi, First Day (cont.)

Salviati: Here again you are in error, Simplicio, because it is not true that the smaller stone adds weight to the larger.
Simplicio: This is, indeed, quite beyond my comprehension. .
Salviati: It will not be beyond you when I have once shown you the mistake under which you are laboring. Note that it is necessary to distinguish between heavy bodies in motion and the same bodies at rest. A large stone placed in a balance not only acquires additional weight by having another stone placed upon it, but even by the addition of a handful of hemp its weight is augmented six to ten ounces according to the quantity of hemp. But if you tie the hemp to the stone and allow them to fall freely from some height, do you believe that the hemp will press down upon the stone and thus accelerate its motion or do you think the motion will be retarded by a partial upward pressure? One always feels the pressure upon his shoulders when he prevents the motion of a load resting upon him; but if one descends just as rapidly as the load would fall how can it gravitate or press upon him? Do you not see that this would be the same as trying to strike a man with a lance when he is running away from you with a speed which is equal to, or even greater, than that with which you are following him? You must therefore conclude that, during free and natural fall, the small stone does not press upon the larger and consequently does not increase its weight as it does when at rest...

”A piece of wooden moulding or scantling, about 12 cubits long, half a cubit wide, and three finger-breadths thick, was taken; on its edge was cut a channel a little more than one finger in breadth; having made this groove very straight, smooth, and polished, and having lined it with parchment, also as smooth and polished as possible, we rolled along it a hard, smooth, and very round bronze ball. Having placed this board in a sloping position, by lifting one end some one or two cubits above the other, we rolled the ball, as I was just saying, along the channel, noting, in a manner presently to be described, the time required to make the descent. We repeated this experiment more than once in order to measure the time with an accuracy such that the deviation between two observations never exceeded one-tenth of a pulse-beat. Having performed this operation and having assured ourselves of its reliability, we now rolled the ball only one-quarter the length of the channel; and having measured the time of its descent, we found it precisely one-half of the former. Next we tried other distances, comparing the time for the whole length with that for the half, or with that for two-thirds, or three-fourths, or indeed for any fraction;”

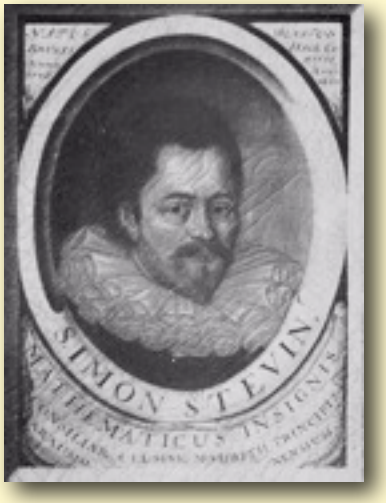
Galileo, *Discorsi* (1638)

”in such experiments, repeated a full hundred times, we always found that the spaces traversed were to each other as the squares of the times, and this was true for all inclinations of the plane, i.e., of the channel, along which we rolled the ball. We also observed that the times of descent, for various inclinations of the plane, bore to one another precisely that ratio which, as we shall see later, the Author had predicted and demonstrated for them. For the measurement of time, we employed a large vessel of water placed in an elevated position; to the bottom of this vessel was soldered a pipe of small diameter giving a thin jet of water, which we collected in a small glass during the time of each descent, whether for the whole length of the channel or for a part of its length; the water thus collected was weighed, after each descent, on a very accurate balance; the differences and ratios of these weights gave us the differences and ratios of the times, and this with such accuracy that although the operation was repeated many, many times, there was no appreciable discrepancy in the results.”

Galileo, *Discorsi* (1638)

Selected results of Galileo concerning mechanics:

- **Principle of (Galilean) relativity**
- **Correct law of free fall**
- **Isochronism of pendulums**
- **The path of a projectile is a parabola**
- **(Incorrect) principle of inertia**



Simon Stevin (1548-1620)

THIENDE

Leerende door onghehoorde lichticheyt allen rekeningen onder den Menschen noodich vallende, afveerdighen door heele ghetalen sonder ghebrokenen.

Beschreven door SIMON STEVIN van Brugghe.

TOT LEYDEN,
By Christoffel Plantijn
M. D. LXXXV

DE
BEGHINSELEN
DES WATERWICHTS
BESCHREVEN DVER
SIMON STEVIN
van Brugghe.

TOT LEYDEN,
Inde Druckerye van Christoffel Plantijn,
By Françoys van Raphelinghen.
CIↃ. IↃ. LXXXVI.

DE
BEGHINSELEN
DER WEEGHCONST
BESCHREVEN DVER
SIMON STEVIN
van Brugghe.

TOT LEYDEN,
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By Françoys van Raphelinghen.
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WEEGHDAET
BESCHREVEN DVER
SIMON STEVIN
van Brugghe.

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CIↃ. IↃ. LXXXVI.

sur P, repose aussi sur I, & partant comme G O à G P, ainsi seront les pesanteurs qui reposent sur I & H.

Conclusion. Une colomne donc reposant, &c.

COROLLAIRE.

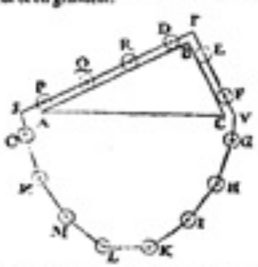
Il est manifeste par ce que devant, que voulant recognoistre la raison de la pesanteur reposant sur I, à celle qui repose sur H, qu'on doit à celle fin mener les perpendiculaires K L, M N, coupant l'axe ès poincts O. P, & que la raison de G O à G P seroit la requise, ainsi donc, lors que la pesanteur de la colomne est notoire, qu'aussi seront les pesanteurs de celles qui reposent sur chacun poinct, tel que H, I.

JUSQUES ICY ONT ESTE declarées les proprietez des pesanteurs droictes, suivent les proprietez & qualitez des obliques, desquelles le fondement general est compris au Theoreme suivant.

THEOREME XI. PROPOSITION XIX.

Si un triangle, a son plan perpendiculaire à l'horizon, & sa base parallele à iceluy, & sur un chacun des deux autres costez un poids sphærique, de pesanteur egale; comme le costé dextre du triangle, au senestre; ainsi la puissance du poids senestre, à celle du poids dextre.

Le donné. Soit A B C un triangle ayant son plan perpendiculaire à l'horizon, & sa base AC parallele à iceluy horizon: & soit sur le costé A B (qui est double à B C) un poids en globe D, & sur B C un autre E, egaux en pesanteur & en grandeur.



Le requis. Il faut demonstrer que comme le costé A B 2 au costé B C 1, ainsi la puissance ou pouvoir du poids E à celle de D.

Preparation. Soit accommodé à l'entour du triangle un entour de 14 globes, egaux en pesanteur, en grandeur, & equidistans, comme D, E, F, G, H, I, K, L, M, N, O, P, Q, R, enfilez d'une ligne passant par leurs centres, ainsi qu'ils puissent tourner sur leurs susdits centres, & qu'il y puisse avoir 2 globes sur le costé B C, & 4 sur B A, alors comme ligne à ligne, ainsi le nombre des globes au nombre des globes: qu'aussi en S, T, V, soyent trois poincts fermes, dessus lesquels la ligne, ou le filet puisse couler, & que les deux parties au dessus du triangle soyent paralleles aux costez d'iceluy A B, B C, tellement que le tout puisse tourner librement & sans accrochement, sur lesdits costez A B, B C.

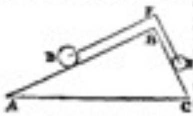
DEMONSTRATION.

Si le pouvoir des poids D, R, Q, P, n'estoit egal au pouvoir des deux globes E, F, l'un costé sera plus pesant que l'autre, donc (s'il est possible) que les 4 D, R, Q, P, soyent plus pesans que les deux E, F, mais les 4 O, N, M, L, sont egaux aux 4 G, H, I, K; parquoy le costé des 8 globes D, R, Q, P, O, N, M, L, sera plus pesant selon leur disposition, que non pas les 6, E, F, G, H, I, K, & puis que la partie plus pesante emporte la plus legere, les 8 globes descendront, & les autres 6 monteront: Qu'il soit ainsi donc, & que D vienne, où O est presentement, & ainsi des autres; voire que E, F, G, H, viennent, où sont maintenant P, Q, R, D, aussi I, K, où sont maintenant E, F: Ce neantmoins l'entour des globes aura la mesme disposition qu'auparavant, & par mesme raison les 8 globes auront le dessus en pesanteur, & en tombant feront revenir 8 autres en leurs places, & ainsi ce mouvement n'auroit aucune fin, ce qui est absurde. Et de mesme sera la demonstration de l'autre costé: La partie donc de l'entour D, R, Q, P, O, N, M, L, sera en equilibre avec la partie E, F, G, H, I, K; que si on oste des deux costez, les pesanteurs egales, & qui ont mesme disposition, comme sont les 4 globes O, N, M, L, d'une part, & les 4, G, H, I, K, d'autre part; les 4 restans D, R, Q, P, seront & demeureront en equilibre avec les 2 E, F; parquoy E aura un pouvoir double au pouvoir de D; comme donc le costé B A 2, au costé B C 1, ainsi le pouvoir de E, au pouvoir de D.

Conclusion. Si un triangle donc a son plan, &c.

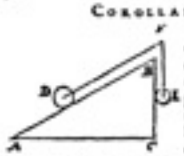
COROLLAIRE I.

Soit A B C un triangle comme devant, & A B double à B C, & soit D un globe sur A B, double à E, qui est sur B C; en F soit un poinct ferme, par dessus lequel la ligne DFE puisse couler sans empeschement, ainsi que D F, F E soyent paralleles aux costez du triangle A B C, procedantes des centres des globes, il appert que D, E seront encor en equilibre, puis que cy-dessus P, Q, R, D, l'estoyent à E, F; parquoy comme A B à B C, ainsi le globe D au globe E.



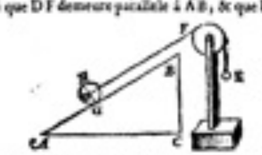
COROLLAIRE II.

Soit maintenant l'un des costez du triangle, comme BC (qui est moitié de l'autre A B) perpendiculaire à AC, comme cy joignant; le globe D, qui est double à E, sera encor en equilibre avec E, car comme le costé AB à BC, ainsi le globe D au globe E.



COROLLAIRE III.

Soient derechef les mesmes posées, mais au lieu du poinct ferme F, soit adaptée une poulie comme icy, ainsi que D F demeure parallele à A B, & que E soit un poids de quelle figure que ce puisse estre, egal en pesanteur à celuy de devant; iceluy avec D, seront encor en equilibre. parquoy comme A B à B C, ainsi D à E.



COROL-

la colomne soit celle qui est comprise entre le fond pour sa base E F, & G E hauteur, assavoir la colomne G E F H.

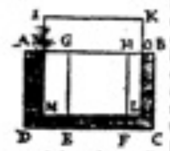
Le requis. Il faut demonstrer que sur le fond E F repose un poids egal à la pesanteur de l'eau de la colomne G E F H.

DEMONSTRATION.

Si sur le fond E F repose un poids plus grand que G E F H, cela viendra à cause de l'eau prochaine: Soit, s'il est possible, de l'eau A D E G, & H F C B; & de mesme pourra-on dire que sur le fond D E repose plus que l'eau A D E G, & sur F C plus que l'eau H F C B; tellement que sur D C reposera plus que l'eau ADCB; ce qui est absurde, estant iceluy un parallelipipede rectangle. Semblablement on demonstrera que sur E F ne repose pas moins que G E F H, & par consequent sur E F reposera precisement un poids egal à la colomne d'eau G E F H.

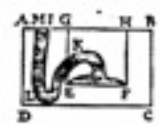
COROLLAIRE I.

En l'eau A B C D de la 10 proposition, mettons I L un corps solide moindregrave à l'eau, c'est à dire flottant sur l'eau, N L dedans, & N K dehors, comme cy-joignant; alors le solide I L, sera equipondérant à l'eau N O L M, par la 5 proposition, d'où s'ensuit que le corps I L, avec le reste de l'eau d'alentour, est equipondérant à un corps d'eau, egal à A B C D; parquoy nous dirons encor selon la proposition, que sur le fond E F, repose un poids egal à la pesanteur de l'eau d'une telle colomne que G E F H, de laquelle E F est la base, & G E perpendicle, entre le fond & la fleur de l'eau pour la hauteur d'icelle: D'où l'on peut conclurre que quand quelque matiere flotte sur l'eau, qu'elle n'apporte aucun changement au poids que le fond soustient lors que l'eau demeure en la mesme hauteur.



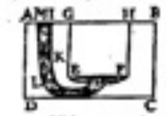
COROLLAIRE II.

Soit encore en l'eau A B C D, un ou plusieurs corps solides parigraves à l'eau, tellement qu'il n'y aye place que pour l'eau I K F E L M, alors ce corps ne surcharge, ny n'allege le fond E F pas plus que devant: Et partant selon la proposition, sur le fond E F, repose un poids egal à la pesanteur de l'eau, laquelle est egale à la colomne, ayant ledit fond pour base, & la hauteur egale à la perpendicle sur l'horizon, qui est entre le fond & fleur d'eau.



COROLLAIRE III.

Soit derechef A B C D entierement eau, E F un fond en icelle parallele à l'horizon; alors l'eau poussera autant par dessous, en elevant que par dessus en abaissant, autrement le plus fort emporteroit le plus foible: ce qui n'arrive pas ainsi, d'autant que tout tient la disposition qu'on luy donne, par la 1 proposition. Soyent maintenant dedans l'eau quelques corps solides parigraves à icelle, & tellement disposés que l'eau I K E F L M pousse par dessous E F, assavoir contre le corps solide, comme devant contre l'eau, mais l'un contrepoussoit egalement l'autre: donc contre E F y a un effort qui le pousse enhaut, de mesme que la colomne d'eau G E F H pousse le mesme fond E F embas, selon la proposition; car la hauteur G E est la perpendicle interceptée entre la fleur de l'eau & le fond E F.

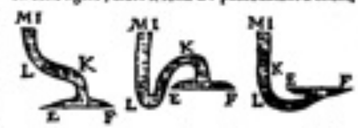


COROLLAIRE IV.

Que si on mettoit les corps solides des deuxiesme & troisiesme corollaires en leurs lieux, & l'eau vuidée, y ayant une place vuide I K F E L M; alors le fond E F ne portera aucune pesanteur; que si on remplit le lieu vuidé, avec de l'eau, le fond patira autant d'effort, que lors que le vaisseau estoit entierement plein d'eau (ayant osté les corps solides.)

COROLLAIRE V.

Mais si on ostoit la matiere inutile des corps solides, & s'il n'y en demeuroit pas d'avantage que pour tenir l'eau en ceste figure; alors le fond E F patira autant d'effort,



que s'il y avoit dessus une colomne d'eau, comprise sur le mesme fond comme base, dont la hauteur soit la perpendicle entre ledit fond & la fleur d'eau.

Conclusion. Sur le fond de l'eau parallele à l'horizon, repose donc un poids, &c.

Lisez les espreuves deduites en l'Appendice de la practique de l'Hydrostatique.

NOTES.

Nous pourrions aussi proposer la 10 proposition comme s'ensuit:

Sur quelconque fond d'eau, de superfice parallele à la fleur d'icelle, repose un poids egal à la pesanteur de l'eau, comprise dans un solide sphærique, tronqué par une superfice sphærique parallele, ou homocentrique à la superfice sphærique de la terre.

Nous eussions fait aussi les demonstrations comme dessus, mais nous l'avons delaissé pour les raisons descrites en la septiesme petition.

THEOREME IX. PROPOSITION XI.

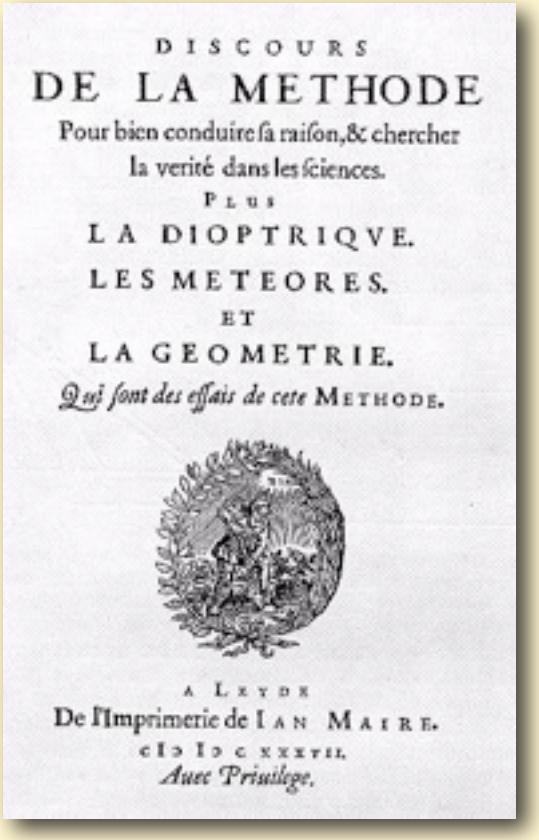
Sur un fond contrevent, duquel le plus haut poinct est à fleur d'eau, repose un poids egal à la demi-colomne d'eau, de laquelle la base est pareille audit fond, & sa hauteur egale à la perpendicle comprise entre les niveaux qui passent par le plus haut & plus bas poinct dudit fond.

1 *Exemple.*

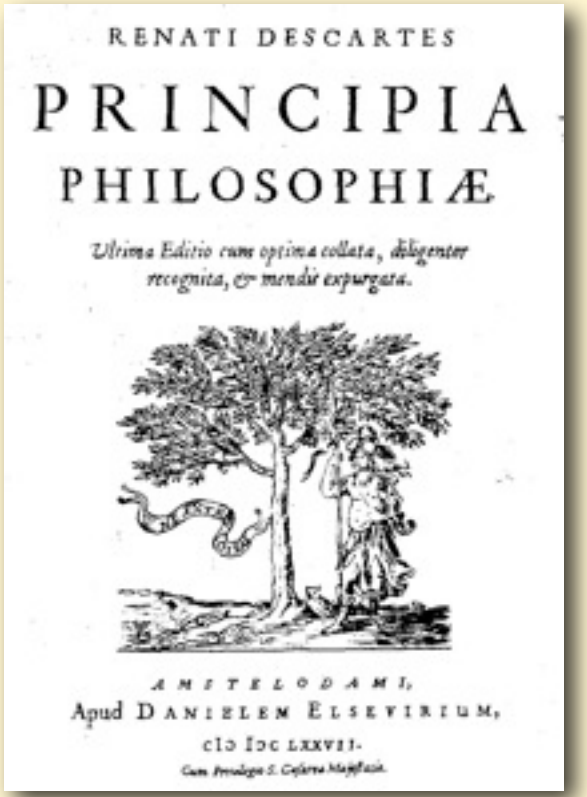
Le donné. Soit A B un vaisseau plein d'eau, & le fond A C D E soit premierement un parallelogramme, non parallele à l'horizon, comme devant, mais perpendiculaire à iceluy; duquel le plus haut costé A C est à fleur d'eau,

René Descartes (1596-1650)

1637 *Discours de la méthode*
1644 *Principia Philosophiae*


DISCOURS
DE LA METHODE
Pour bien conduire ſa raiſon,& chercher
la verité dans les ſciences.
PLUS
LA DIOPTRIQVE.
LES METEORES.
ET
LA GEOMETRIE.
Qui ſont des eſſais de cete METHODE.

A LEYDE
De l'Imprimerie de IAN MAIRE.
cIↃ IↃ C XXXVII.
Auec Priuilege.


RENATI DESCARTES
PRINCIPIA
PHILOSOPHIÆ

Vltima Editio cum optima collata, diligenter recognita, & mendis expurgata.

AMSTELODAMI,
Apud DANIELEM ELSEVIRIUM,
cIↃ IↃC LXXVII.

Descartes, *Discourse on the Method*

”...instead of the great number of precepts of which Logic is composed, I believed that the four following would prove perfectly sufficient for me...

The first was never to accept anything for true which I did not clearly know to be such...
The second, to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution.
The third, to conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex;
And the last, in every case to make enumerations so complete, and reviews so general, that I might be assured that nothing was omitted.”

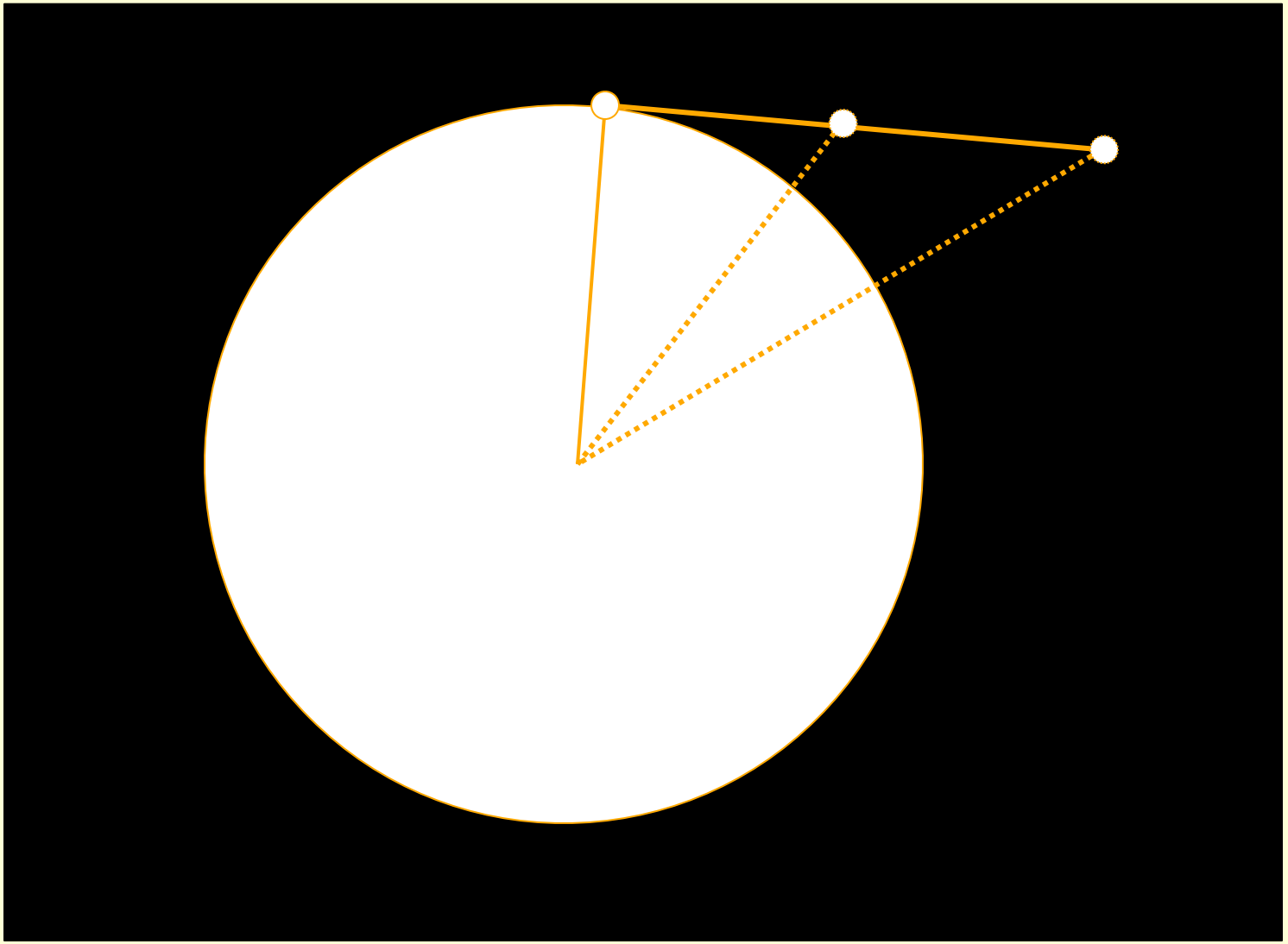
”....Laws of nature, of which the first is that every thing, considered as simple and undivided, perseveres, as far as it can, in the same state and never changes [its state] but for external causes... If it is at rest, we do not believe that it will ever begin to move if not compelled by some cause. Nor is there any reason to think that, if it moves... and is not impeded by anything, it should ever by itself cease to move with the same force. It is therefore to be concluded that a thing which moves, will move forever as far as it can...
The first law of nature, that everything, as much as in it lies, perseveres always in the same state; thus that which once started to move will continue to move forever.
Second law: that every motion by itself is along a straight line and therefore every body which is moved circularly tends perpetually to recede from the centre of the circle which it describes.”

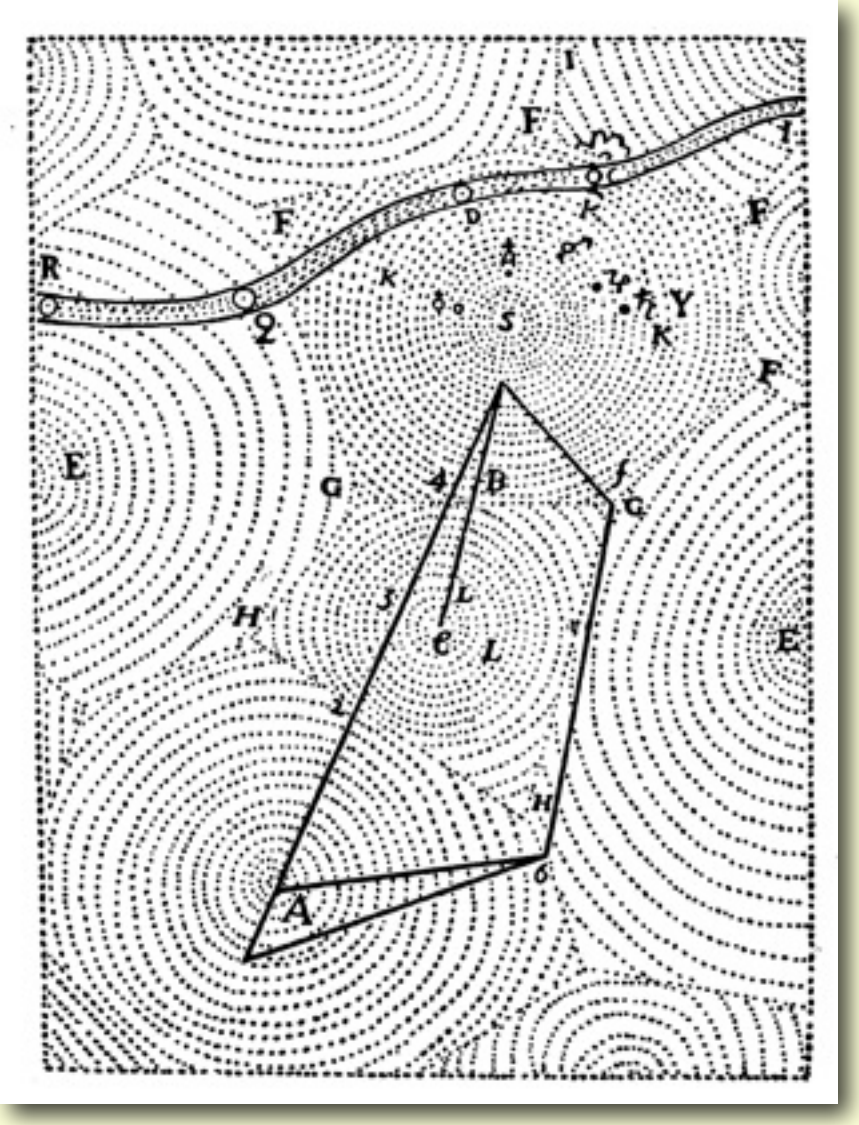
Descartes, ***Principia philosophiae*** (1644)

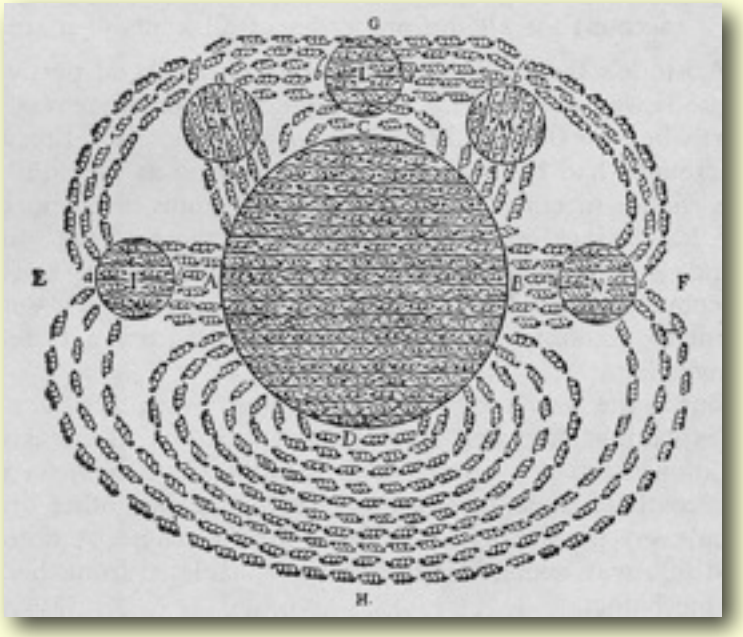
Principle of inertia:
Every isolated body remains in its state, at rest or in rectilinear motion.
Hence bodies in a circular motion always tend to recede from the centre (*conatus recedendi a centro)*

Descartes, *Principia philosophiae* (1644)

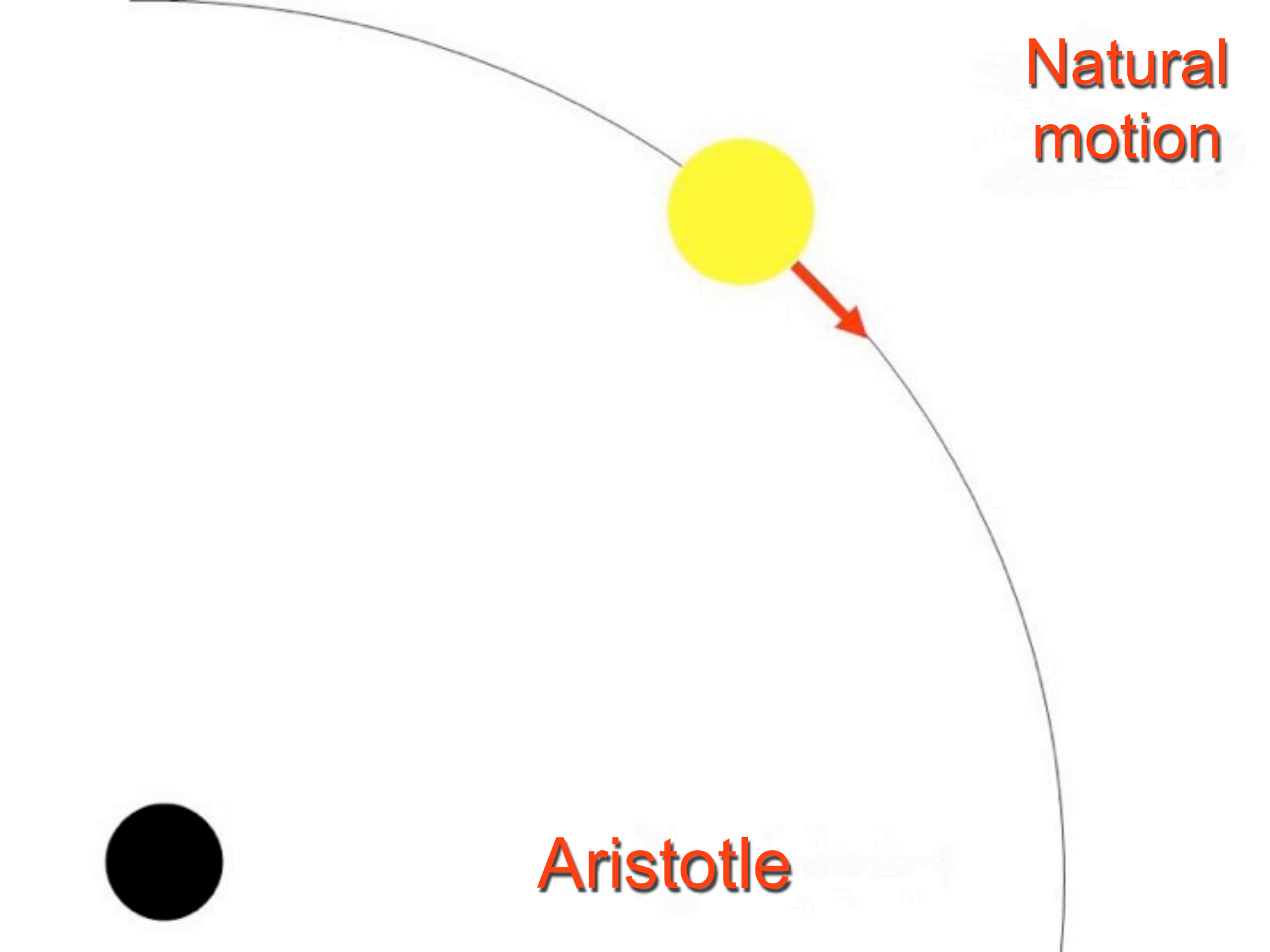
Descartes: *Conatus recedendi a centro*

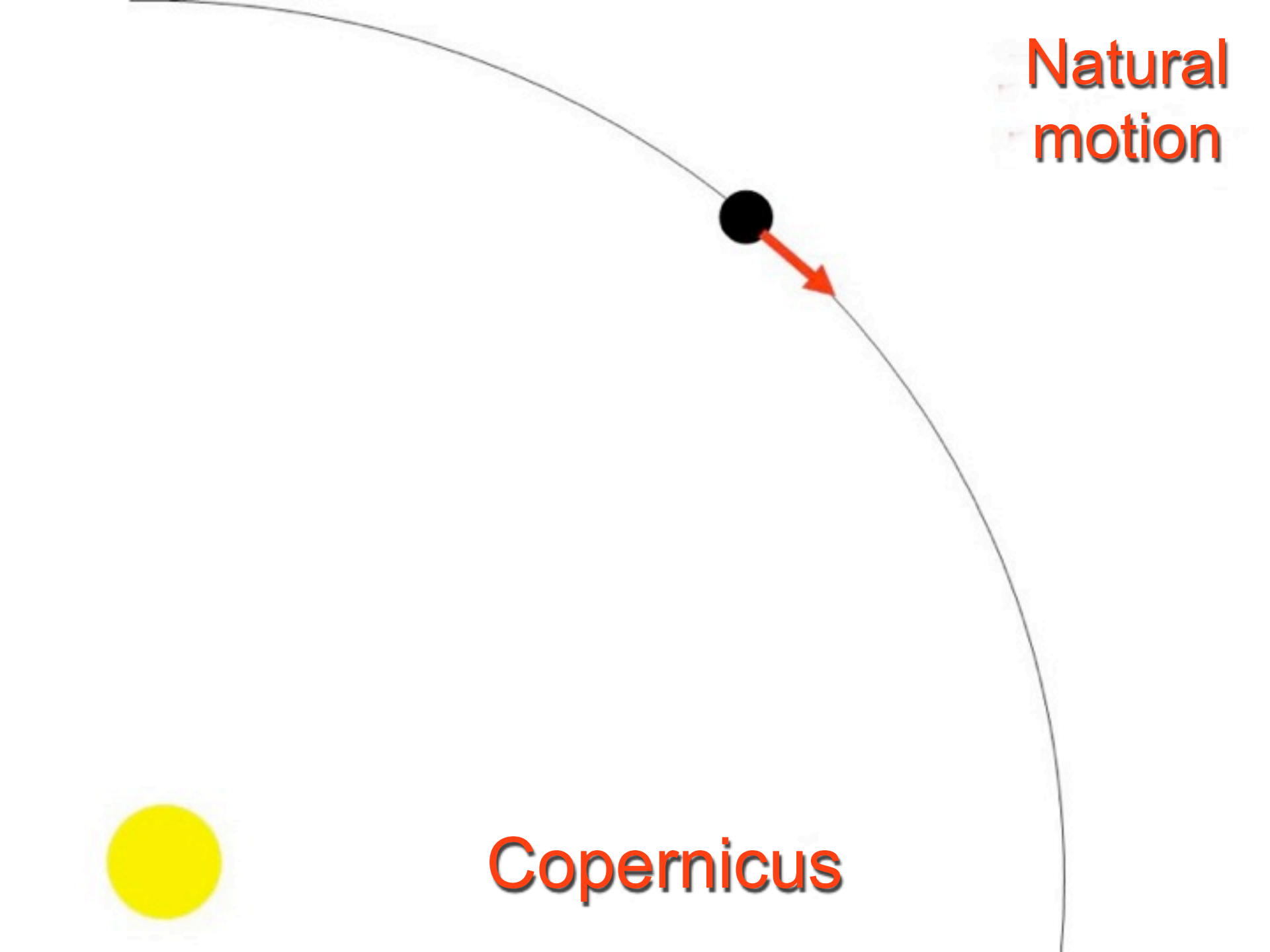


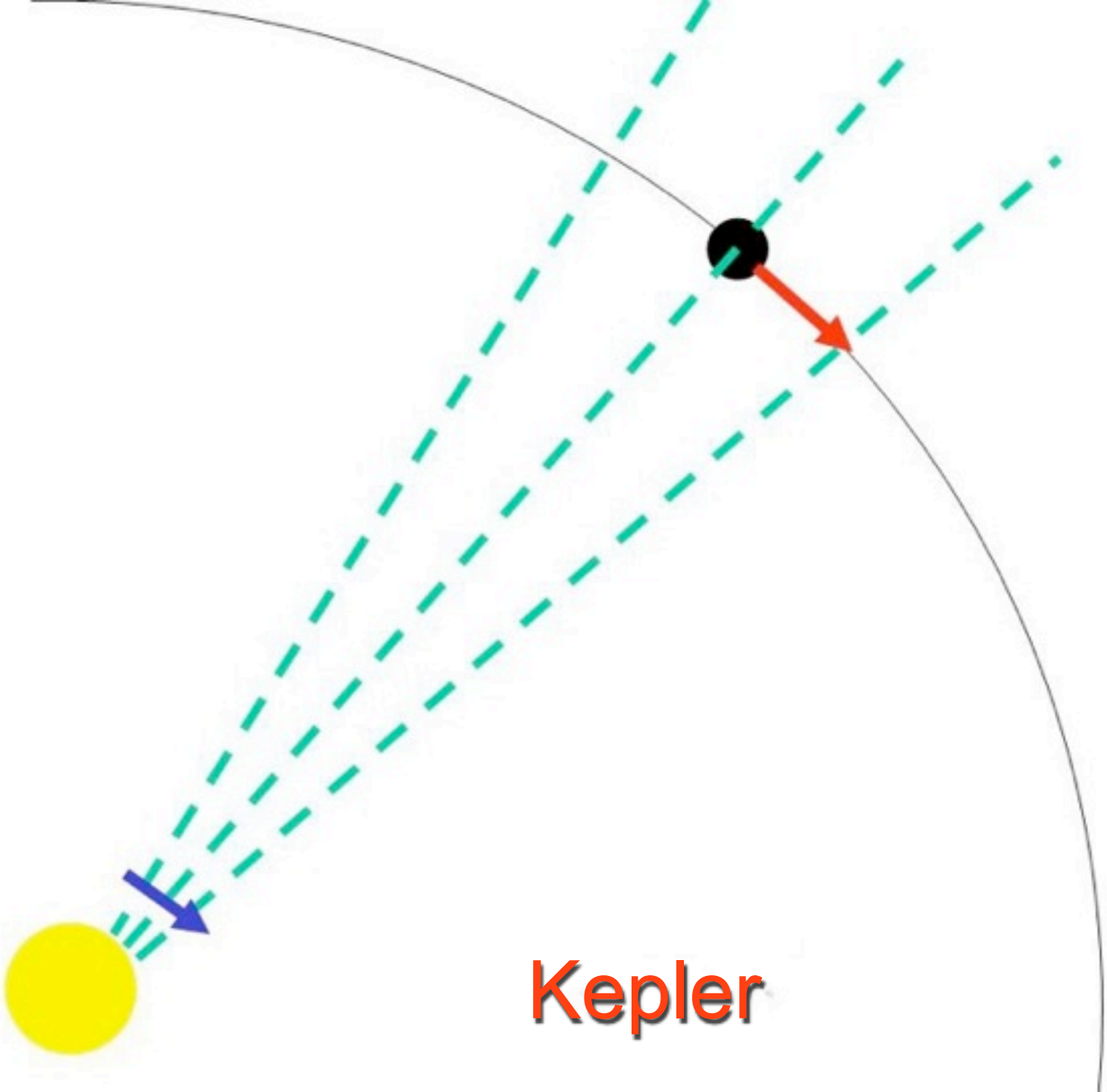


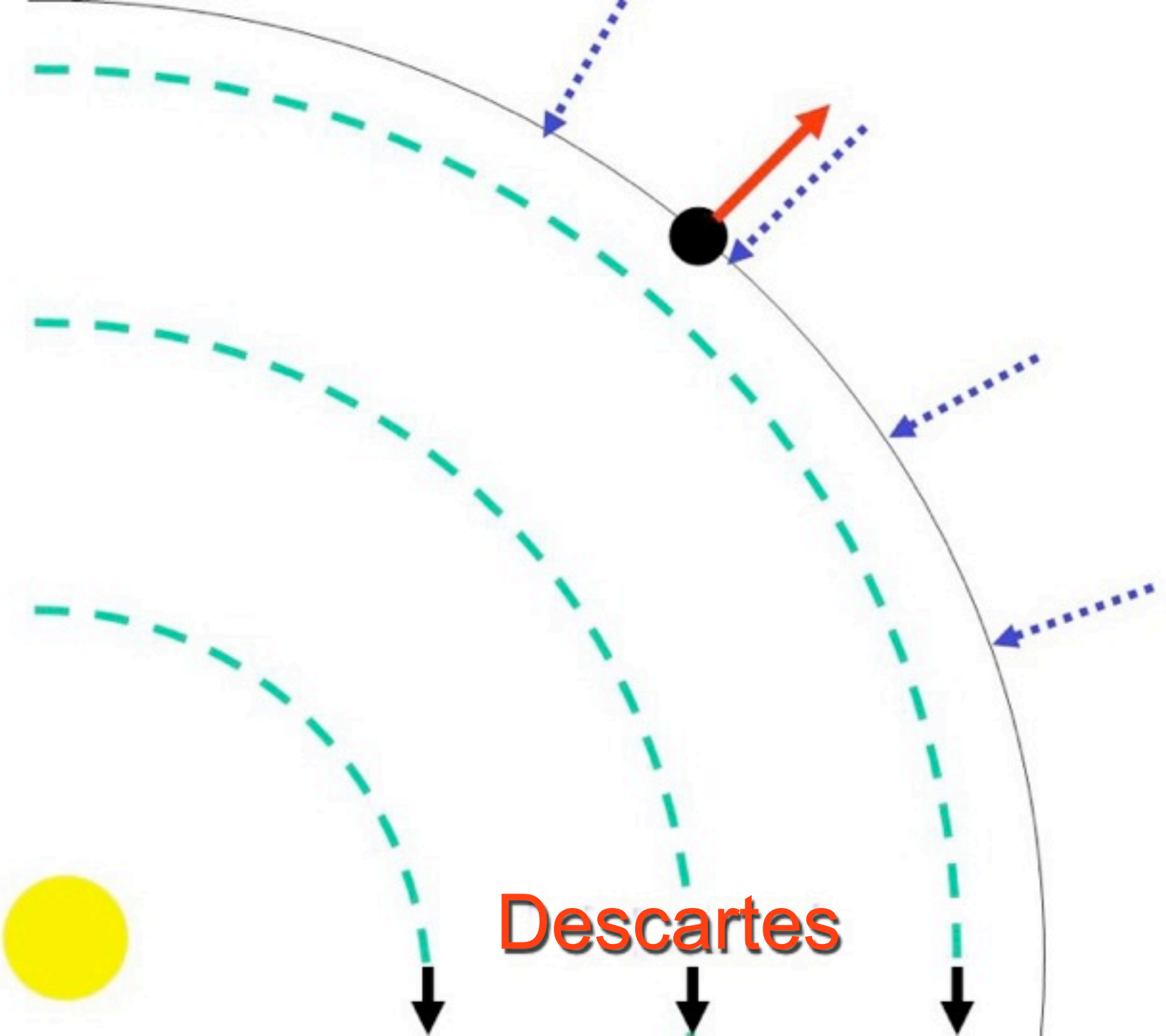


Cartesian vortices, *Principia philosophiae*, 1644


Natural
motion
Aristotle


Natural motion
Copernicus


Kepler


Descartes

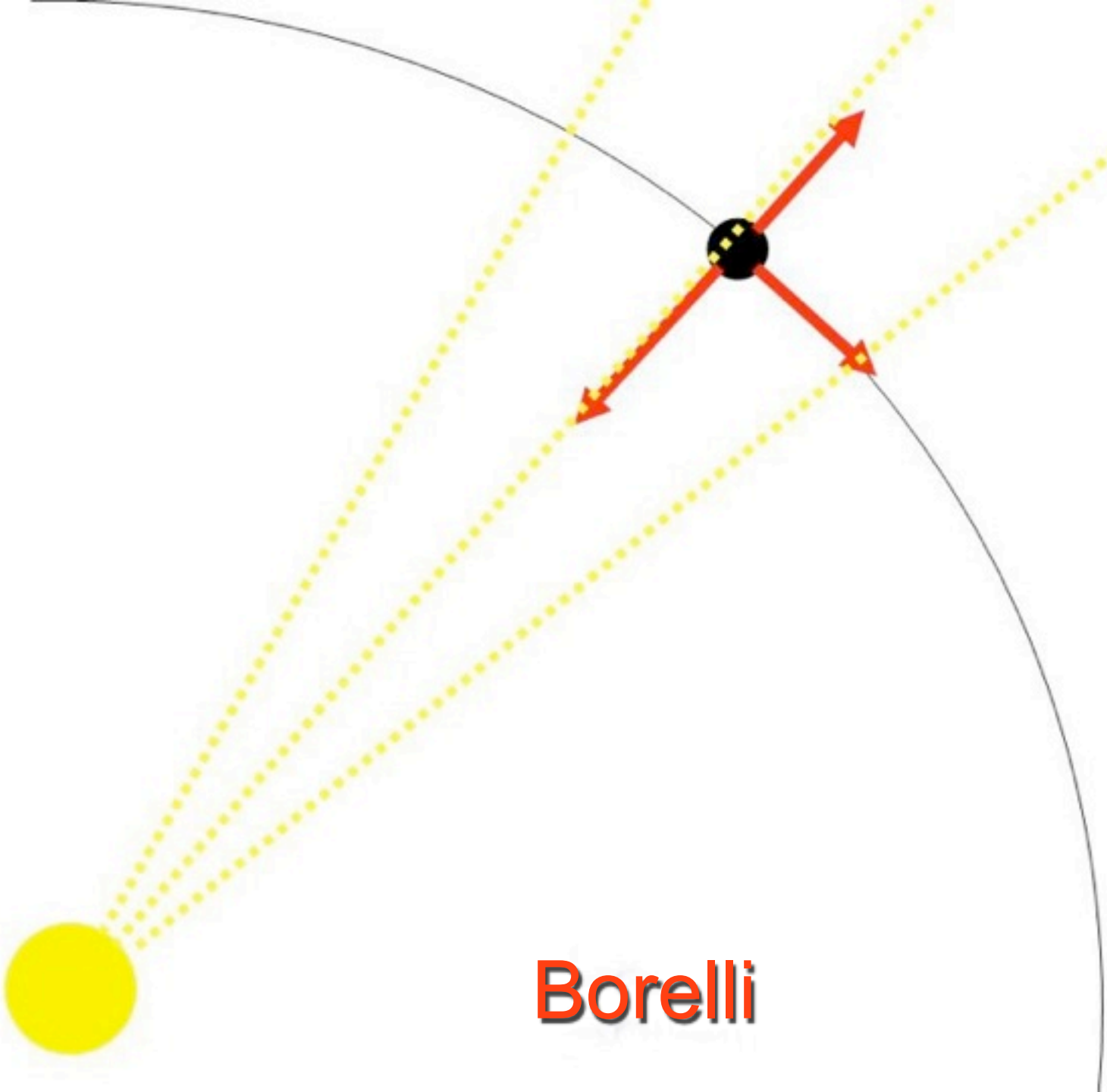
A quantitative expression for *conatus*

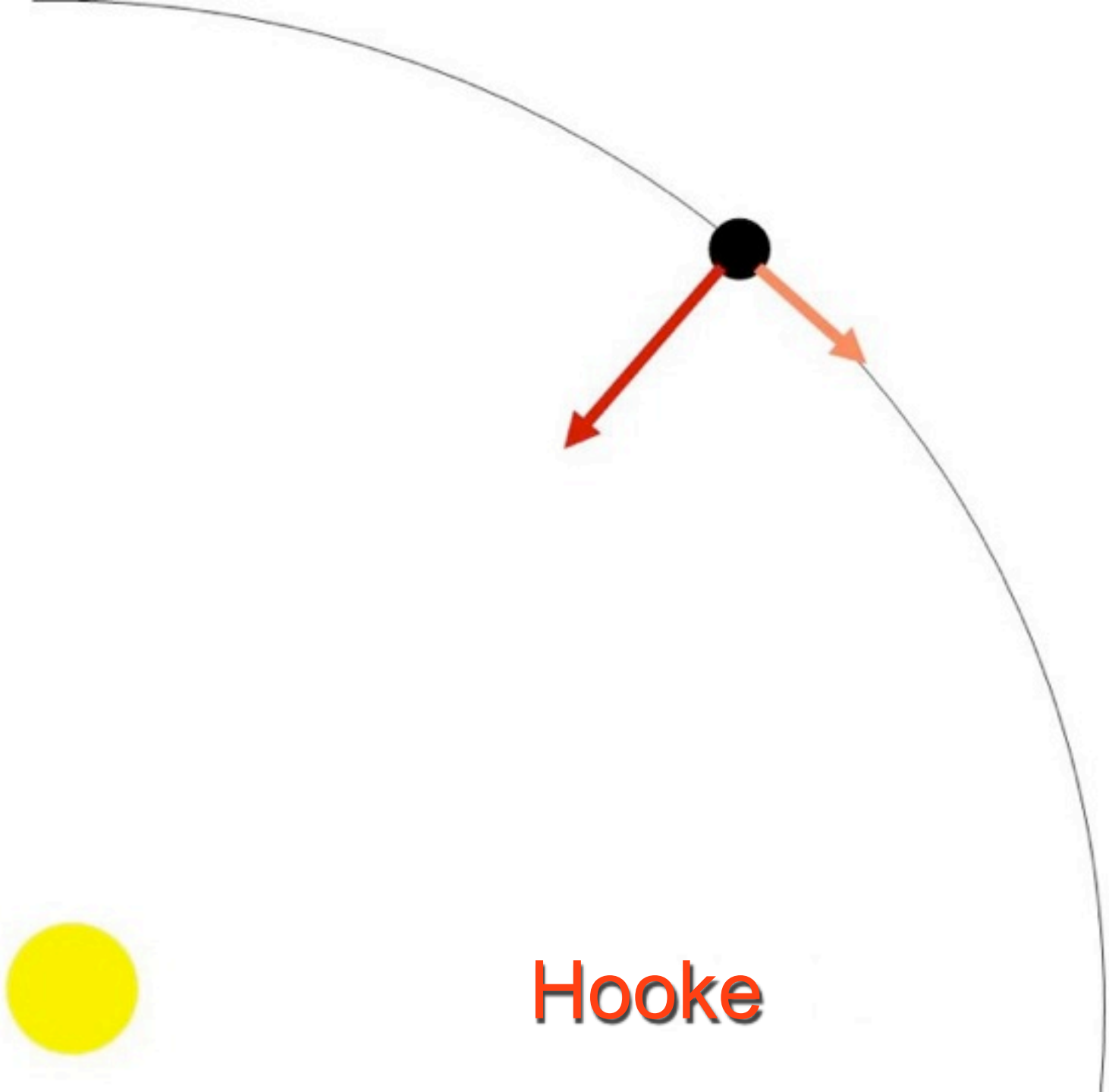
$$v = 2\pi r/T$$

$$v^2 \sim r^2/T^2 = r^3/rT^2 \rightarrow v^2 \sim 1/r$$

$r^3 \sim T^2$ (Kepler)

$$F \sim v^2/r \sim 1/r^2$$


Borelli


Hooke

Robert Hooke, Lectures given to the Royal Society in 1670 (published in London in 1674)

”I shall...explain a system of the world differing in many particulars from any yet known, but answering in all things to the common rules of mechanical motions. This depends upon three suppositions: *First*, That all celestial bodies whatsoever have an attraction or gravitating power towards their own centres, whereby they attract not only their own parts, and keep them from flying from them, as we may observe the Earth to do, but that they also do attract all other celestial bodies that are within the sphere of their activity, and consequently that not only the Sun and Moon have an influence upon the body and motion of the Earth, and the Earth upon them, but that Mercury, Venus, Mars, Jupiter, and Saturn also, by their attractive powers, have a considerable influence upon its motion, as in the same manner the corresponding attractive power of the Earth hath a considerable influence upon every one of their motions.”

Robert Hooke (1670) cont.

”The *second* supposition is this, that all bodies whatsoever that are put into a direct and simple motion, will so continue to move forward in a straight line till they are, by some other effectual powers, deflected, and sent into a motion describing a circle, ellipsis, or some other more compounded curve line. The *third* supposition is, that these attractive powers are so much the more powerful in operating by how much the nearer the body wrought upon is to their own centre. Now, what these several degrees are, I have not yet experimentally verified, but it is a notion which, if fully prosecuted, as it ought to be, will mightily assist the astronomers to reduce all the celestial motions to a certain rule...”

”The importance of Hooke’s statement of the mechanical elements of orbital motion cannot be exaggerated. Following the pattern established by Descartes, every student of circular motion before him had spoken of the tendency of bodies in circular motion to recede from the centre. It was Hooke who broke the tyranny that pattern exercised and reconceptualized the problem. If the principle of inertia is given, the question is what constrains a body to follow a curved path and not the tendency to recede that it exhibits when so constrained. It is not too much to say that Hooke taught the science of mechanics this fundamental lesson and set it on the way to a satisfactory dynamics of circular motion.”

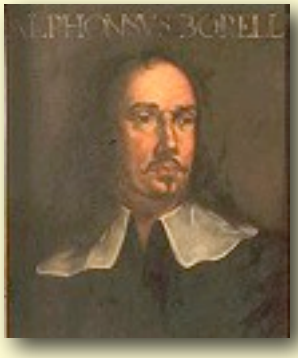
Richard Westphall, *Force in Newton’s Physics*

Copernicus

Descartes

Kepler

Huygens



Borelli

Hooke

Newton

Giovanni Battista Riccioli

Almagestum novum astronomiam veterem novamque complecetens
(1651)

The list is given
of 77 arguments against the Copernican system and only 20 arguments in its support (which are anyway rejected)
Thus, by counting the arguments the falsity of the Copernican system is ”proven”

Anagrams

Galileo (1610) SMAISMRMILMEPOETALEVMIBVNENVGTTAVIRAS
Solution: ALTISSIMUM PLANETAM TERGEMINUM OBSERVARI

Huygens (*De Saturni Luna Observatio Nova*, 1656)
AAAAAAA CCCCC D EEEEE G H IIIIIII LLLL MM NNNNNNNNN OOOO Q RR S TTTTT UUUUU
Solution (*Systema Saturni*, 1659): Annulo cingitur, tenui, plano, nusquam cohaerente, ad eclipticam inclinato

Hooke (1676) ceiiinosssttuu
Solution (1678): Ut tensio sic vis

Newton in a letter to Leibniz (1676)
6a cc d ae 13e ff 7i 3l 9n 4o 4q rr 4s 9t 12v x
Solution: Date equatione quotcunque fluentes quatitates involvente, fluxiones invenire et vice-versa

Scientific academies

Academia Secretorum Naturae - 1560
Naples, Giambattista della Porta
Accademia dei Lincei - 1603-1630
Rome, Prince Federico Cesi
Accademia del Cimento - 1657-1667
Florence, Prince Leopold de Medici
Royal Society (of London for Improving Natural Knowledge) - 1660, 1662, London
Académie des Sciences - 1666
Paris, Jean Baptiste Colbert

Scientific periodicals

Journal des Sçavans (I 1665, Paris)
Philosophical Transactions (III 1665, London)
Acta Eruditorum (1682, Leipzig)

PHILOSOPHICAL TRANSACTIONS:

GIVING SOME

ACCOMPT

OF THE PRESENT

Undertakings, Studies, and Labours

OF THE

INGENIOUS

IN MANY

CONSIDERABLE PARTS

OF THE

WORLD

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LE

IOVRNAL DES SCAVANS.

Du Lundy V. Ianvier, M. DC. LXV.

Par le Sieur DE HEDOVVILLE.

A PARIS,

Chez IEAN CVSSON, ruë S. Iacques, à l'Image de S. Iean Baptiſte.

M. DC. LXV.

AVEC PRIVILEGE DV ROY.

King Louis XIV visiting
the Académie des sciences

Colbert presenting members of the Academy to king Louis XIV