

Galilei Newton and Halley
Telescopes, Apples and Comets

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Galileo **GALILEI**

(1564-1642)





born in Pisa (Italy)



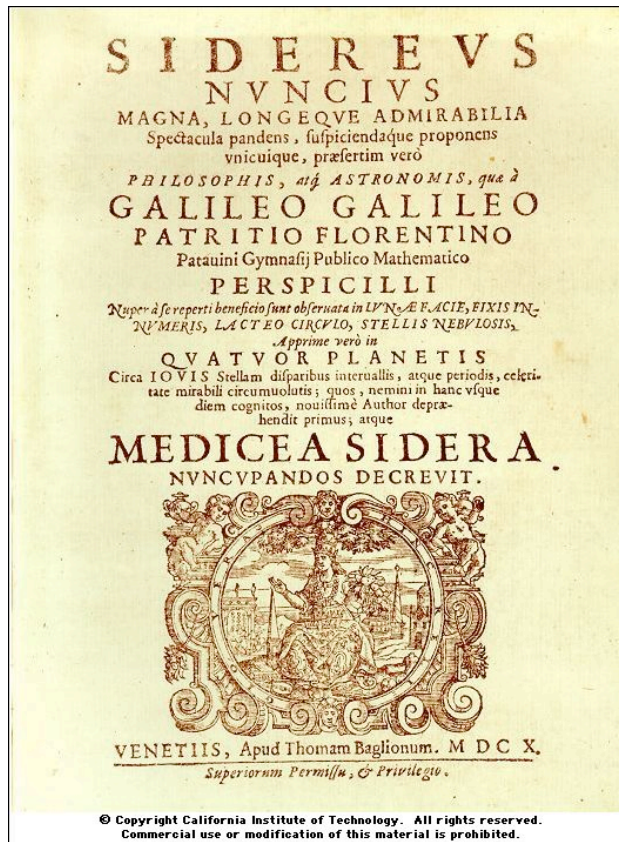
Duomo

observes oscillations of lamp \rightsquigarrow clock

studies **free fall** by dropping objects from **leaning tower**



1610 Galilei publishes



“Sky messenger”



Observes sky using TELESCOPE

TELESCOPE



Shop of Optician 16th century.



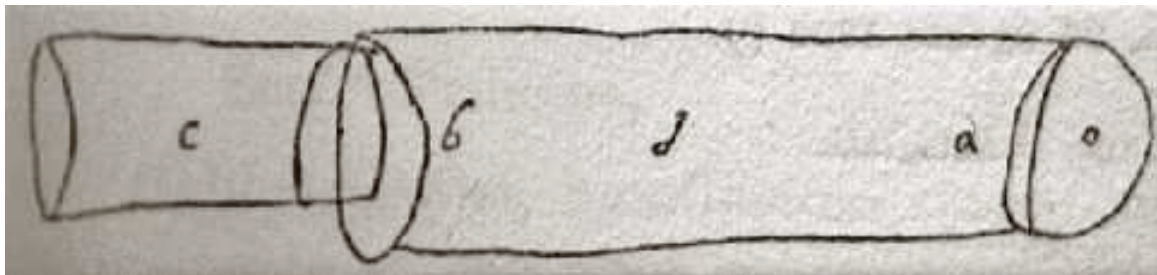
1608 Holland

Lippershey

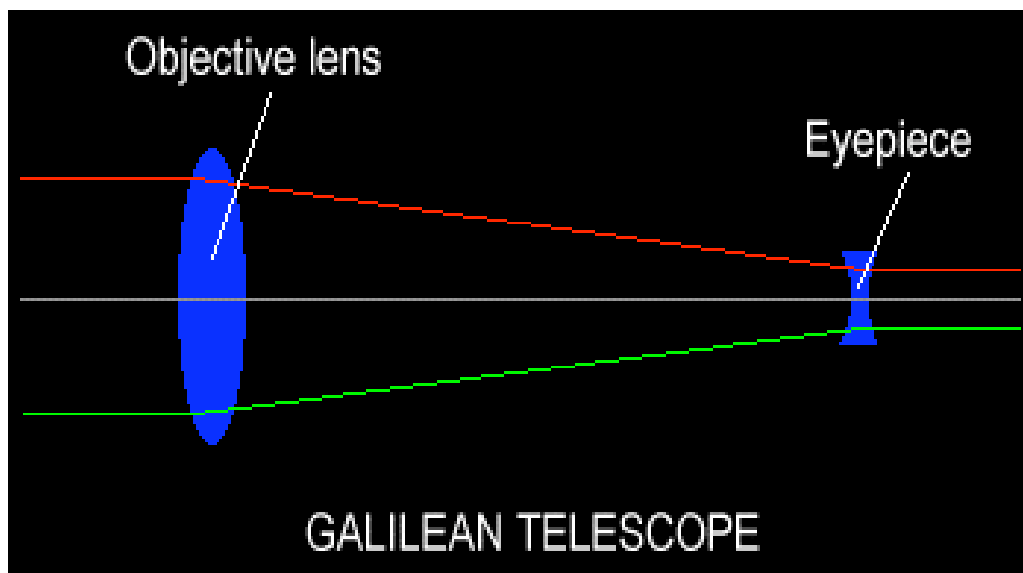
Patent request - refused

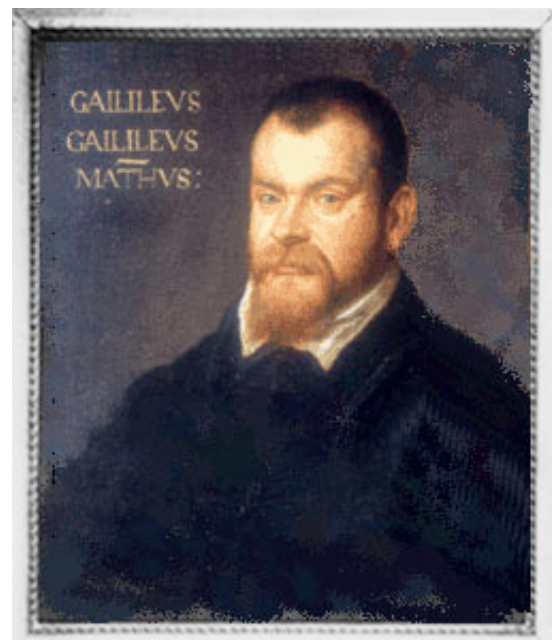
telescopes sold on various markets throughout Europe

1609 Della Porta writes to Galilei

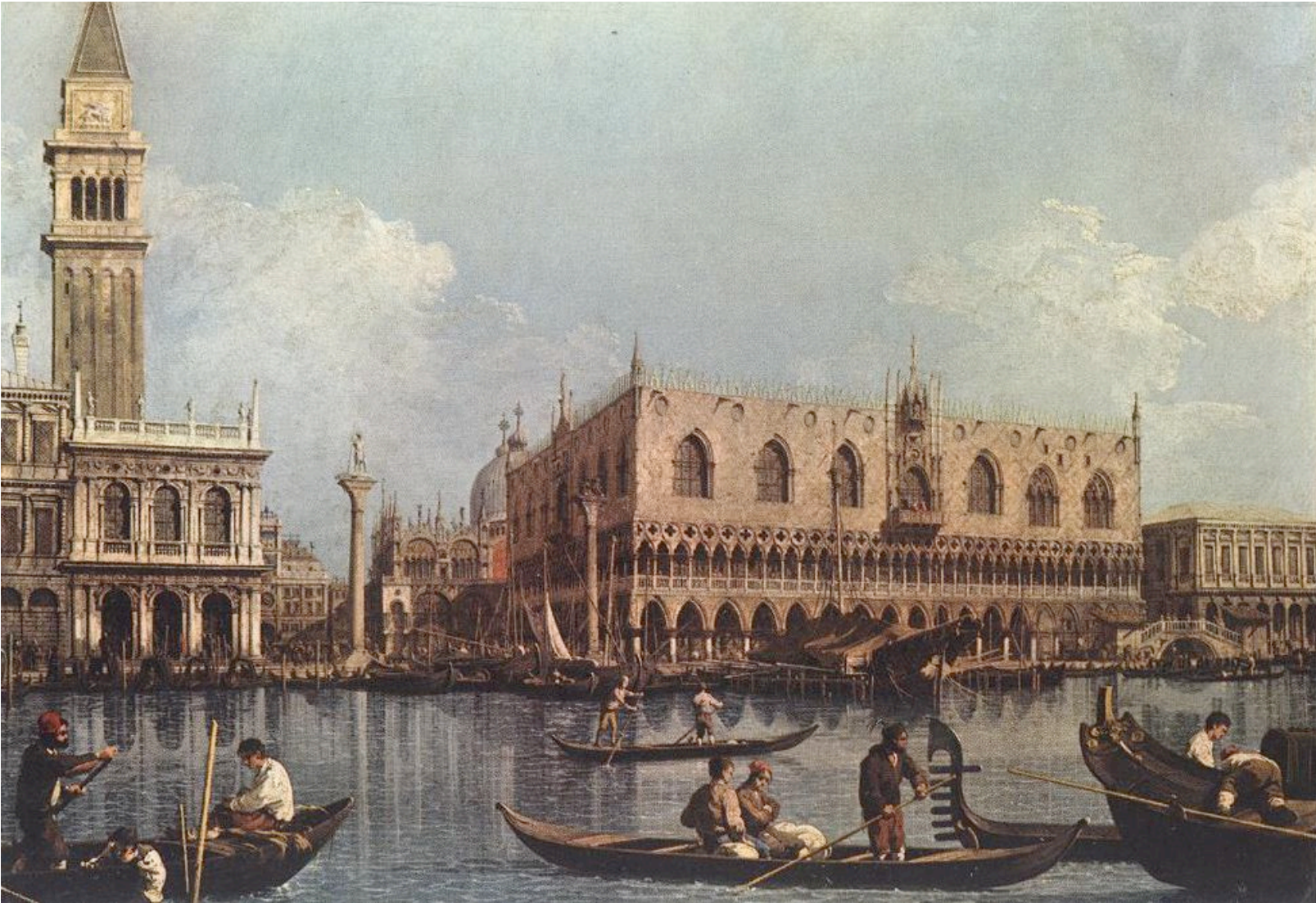


who constructs one of his invention





Proposes as “secret weapon”, to city government of Venezia



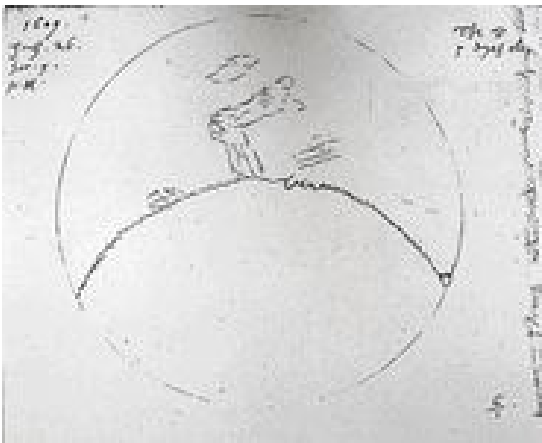
Appointed for life at Padova university.

Astronomical Observations



1609 Thomas Harriot
Moon

observes



Galilei “sells” Jupiter moons to Medici dukes,
rulers of Firenze



Panorama of Firenze (= Florence)



Firenze Palazzo Vecchio (local government)



David of Michelangelo



Duomo Santa Maria del fiore



Firenze ruled by Medici family

SIDEREVS NUNCIVS

MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò

PHILOSOPHIS, atq̃ ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO

Patauini Gymnasij Publico Mathematico

PERSPICILLI

Nuper à se reperti beneficio sunt observata in LVNÆ FACIE, FIXIS IN-
NUMERIS, LACTEO CIRCULO, STELLIS NEBVLOSIS,

Apprime verò in

QVATVOR PLANETIS

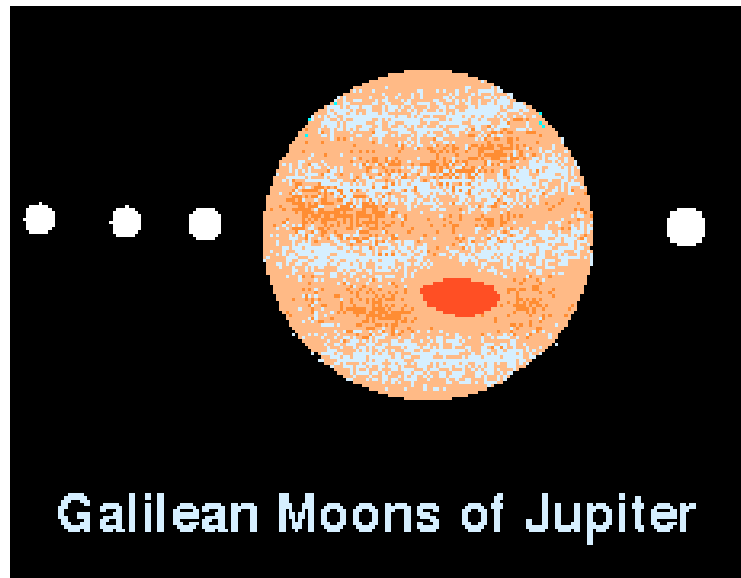
Circa IOVIS Stellam disparibus intervallis, atque periodis, celeri-
tate mirabili circumvolutis; quos, nemini in hanc vsque
diem cognitos, nouissimè Author depræ-
hendit primus; atque

MEDICEA SIDERA.
NUNCVPANDOS DECREVIT.



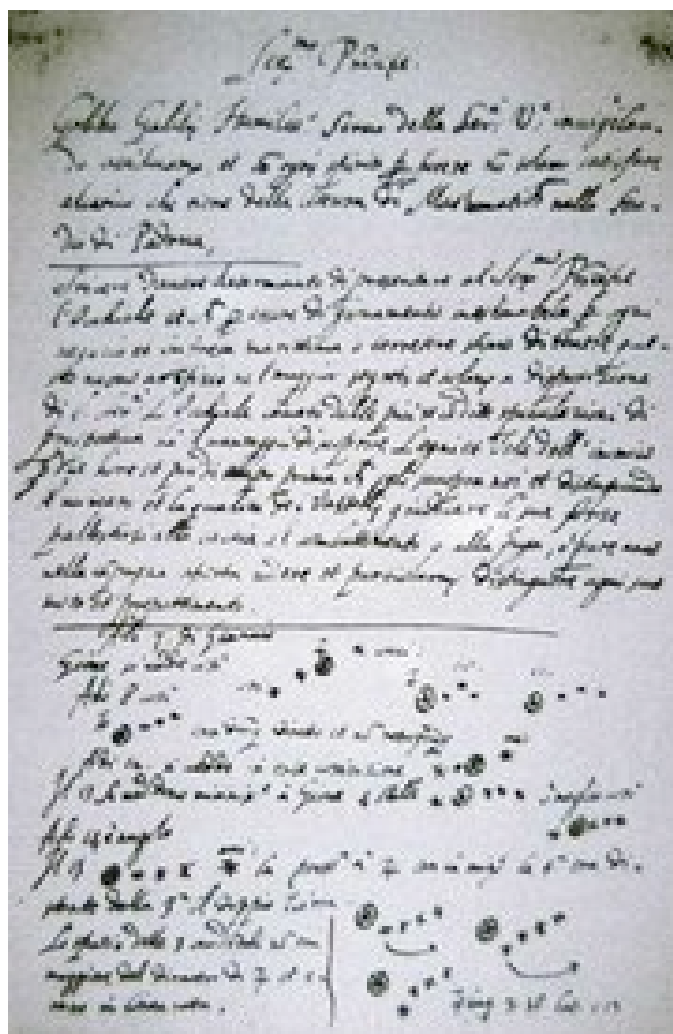
VENETIIS, Apud Thomam Baglionum. M D C X.

Superiorum Permissu, & Privilegio.



Observes **Jupiter**

4 “Medicean stars” – moons of Jupiter [27]



Galilei “Science Advisor” of
Grand Duke



Cosimo II Medici

MOEDICEORVM PLANETARVM

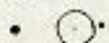
ad inuicem, et ad IOVEM Constitutiones, futurae in Mensibus Martio
et Aprile An: MDCXIII. à GALILEO G.L. earundem

Stellarū, nec non Periodicorum ipsarum motuum

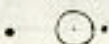
Repertore primo, Calculis collectae ad
Meridianum Florentiae

Martij

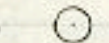
Die 1 Hor. 3 ab Occasu.



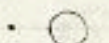
Hor. 4



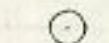
Hor. 5



Die 2 H. 3



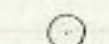
Die 3 H. 3



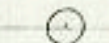
Die 4 H. 3



Die 5 H. 2.

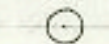


H. 3 Pars versus Ortum



Pars versus occ.

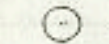
Die 6 H. 1. 30



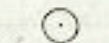
H. 3



Die 7 H. 2.



Die 8. H. 2.



Die 9 H. 3



Die 10. H. 3.



Die 11. H. 2.



Die 12 H. 2.



H. 3.



H. 4.



H. 5.



notes : Red Spot turns



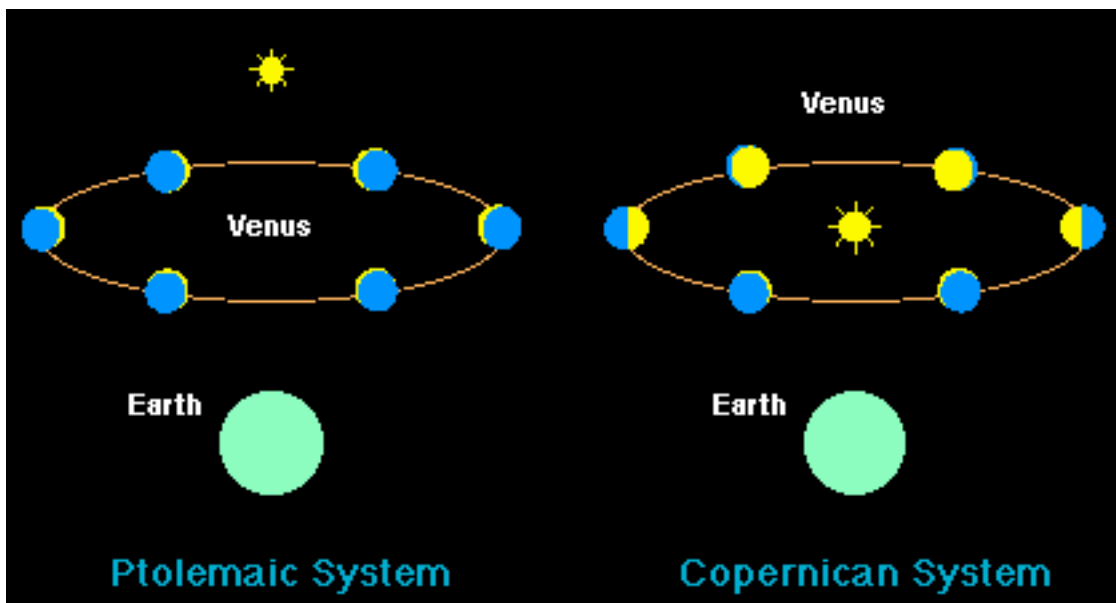
⇒ Jupiter rotates



observes Moon-like phases of Venus

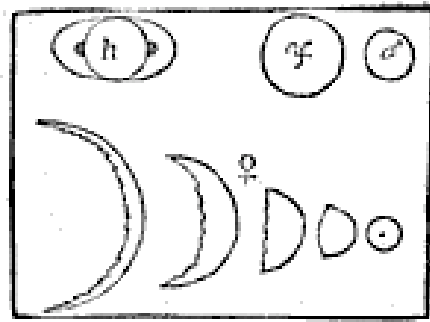


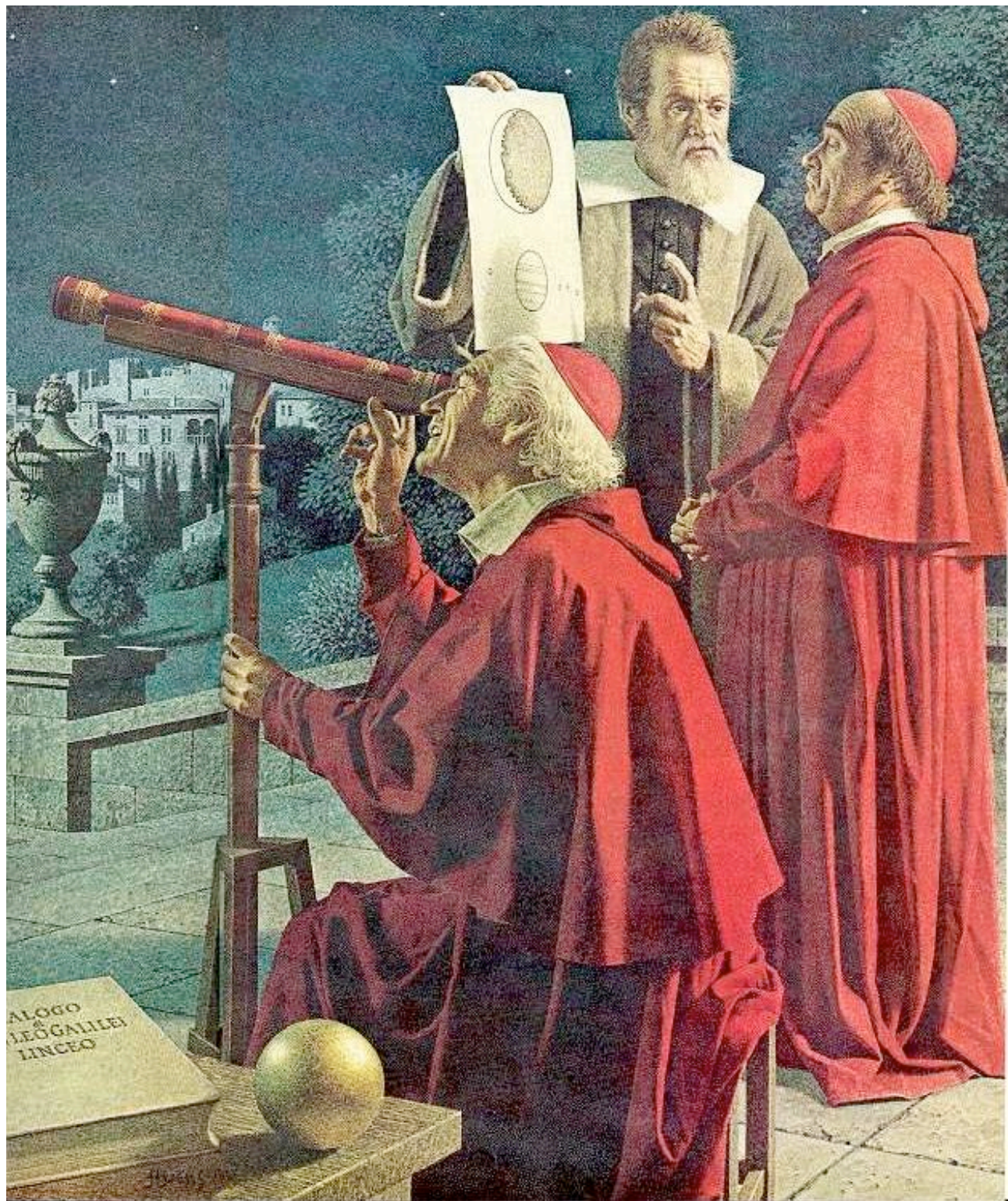
~ like Moon



Considers as proof of Copernican system.

- Saturn planet with “ears”





- Moon





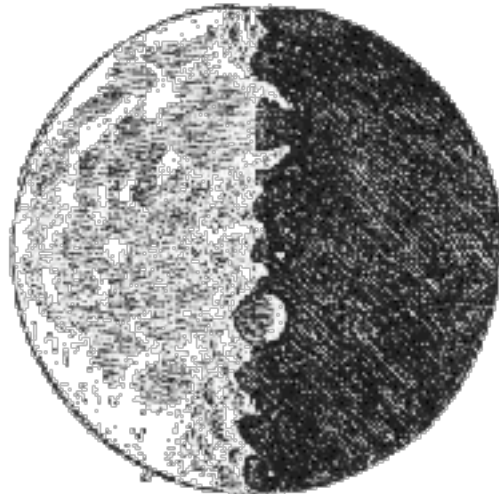
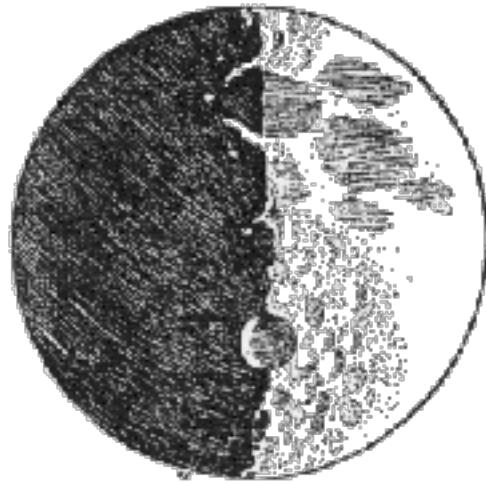
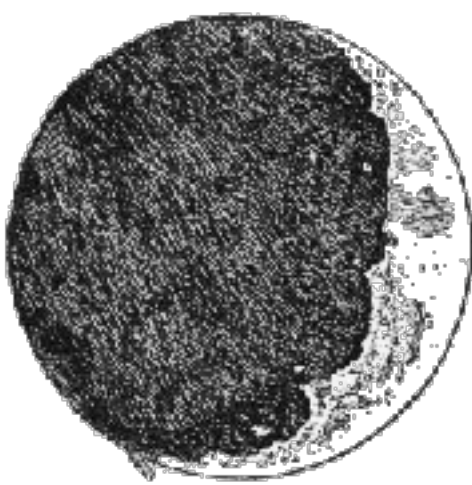
Leonardo da Vinci 1506

thought the Moon was flat, illuminated by

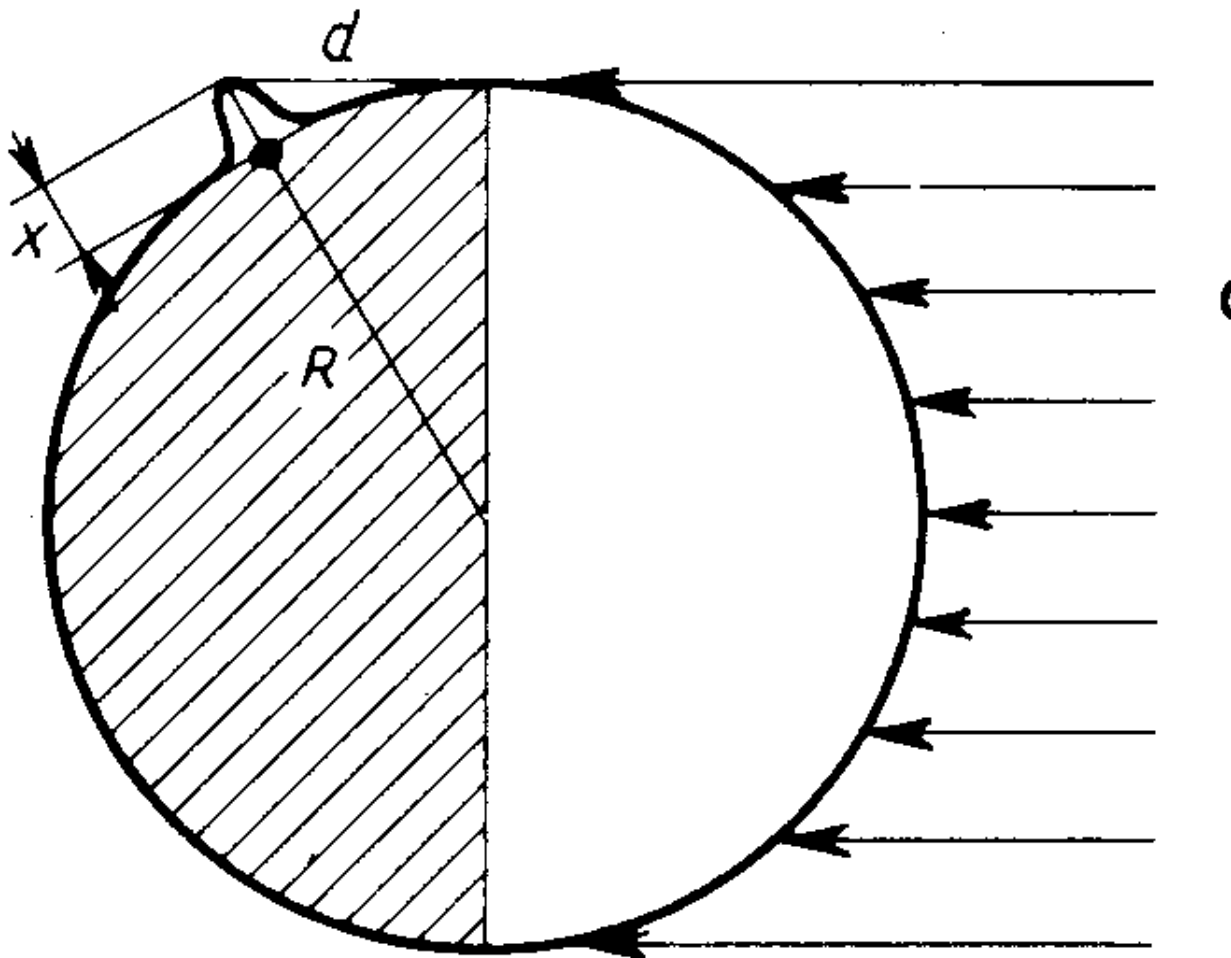


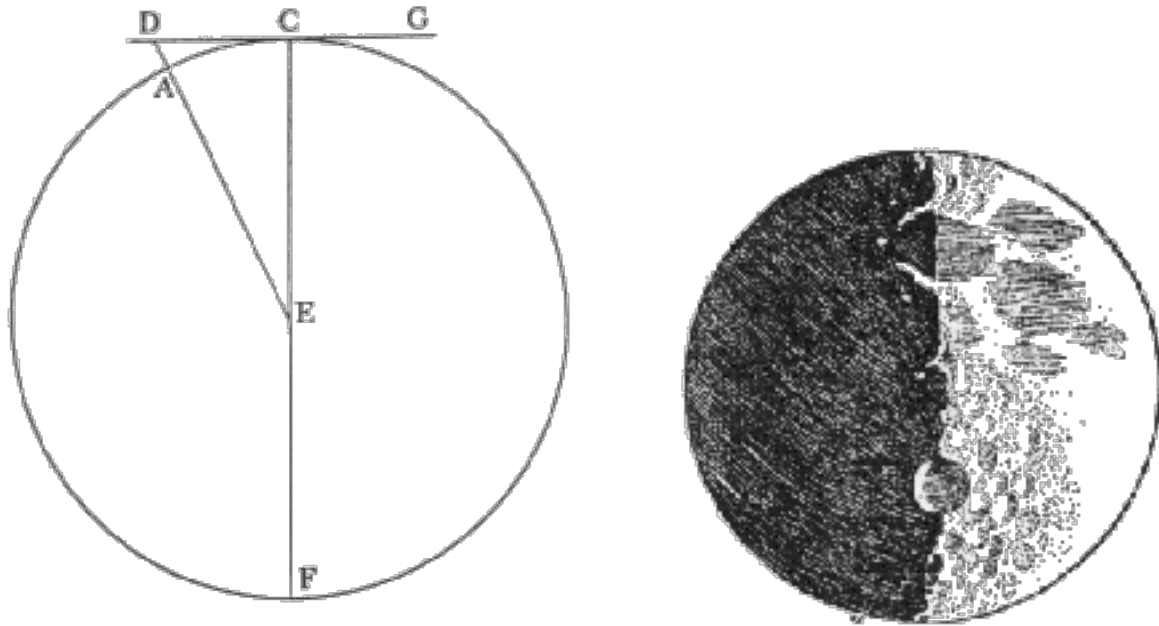
reflexion on surface of water

Galilei 1609 : observes Mountains on the Moon



Galilei measures the heights of the mountains





At half-moon : enlightened points in shade = mountain peaks. Distance from border illuminated/obscure

$$DC \approx \frac{1}{20} \times CF. \quad (1)$$

Pythagoras' THM

$$(DA + AE)^2 = DC^2 + CE^2 \Rightarrow DA \approx \frac{DC^2}{CF} \quad (2)$$

$$DC \approx CE/10; CF \approx 2/7(\text{Earth's diameter})$$

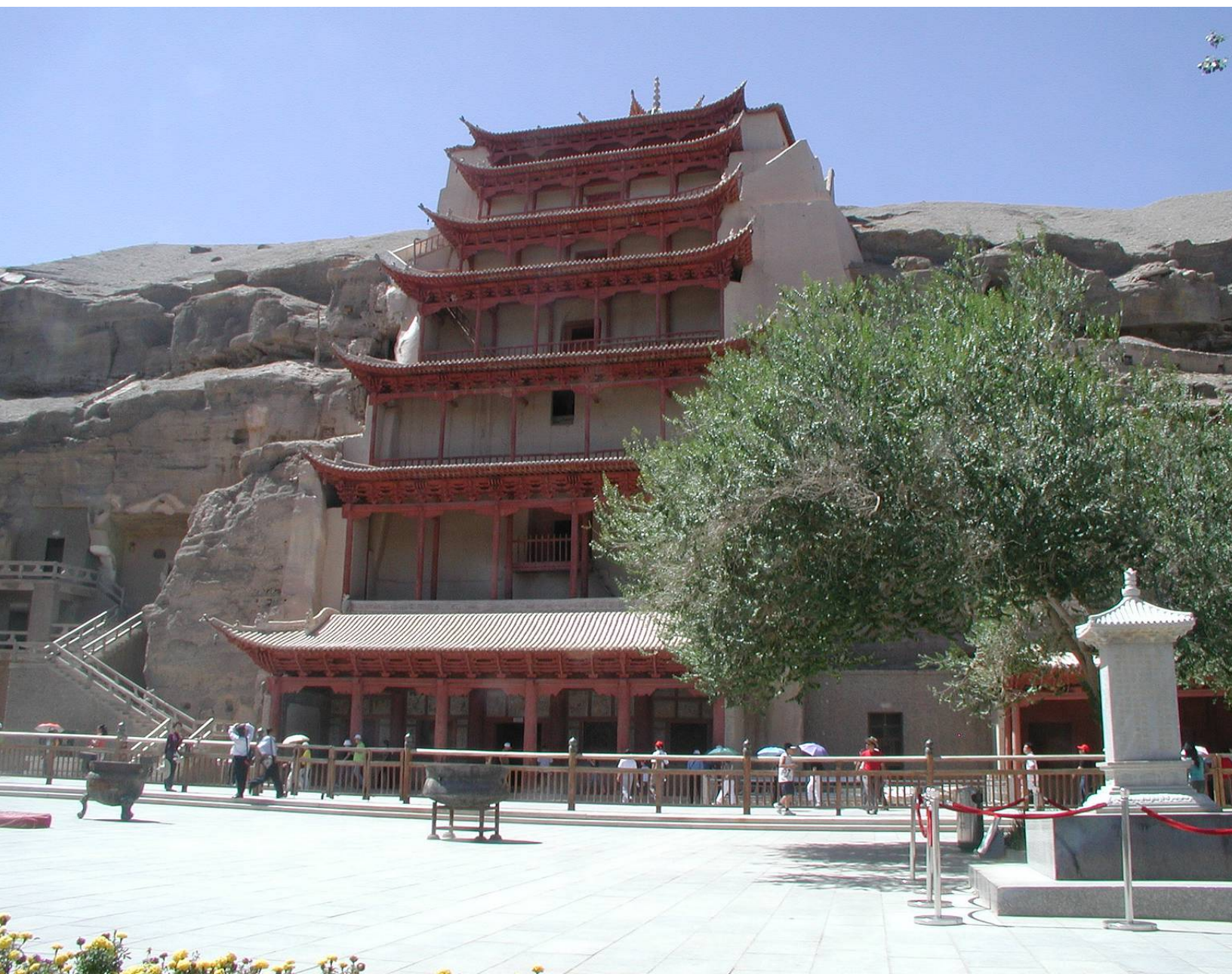
$$DA \approx \frac{1}{700} \times (\text{Earth' radius}) \approx 9,1 \text{ km} \quad (3)$$

- Milky Way splits into a multitude of stars

CINGULI ET ENSIS ORIONIS ASTERISMUS



Orion constellation 9 → 80 stars



Mogao Caves



NEBULOSA ORIONIS



Orion cloud



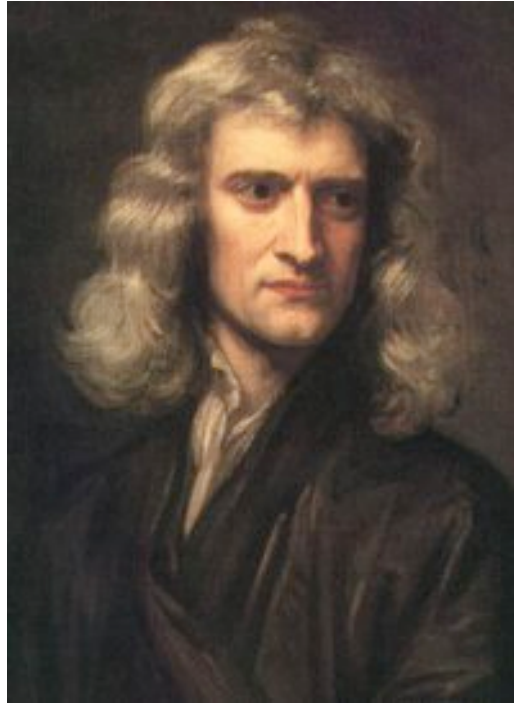
PLEIADUM CONSTELLATIO



Pleiades 7 stars → 36

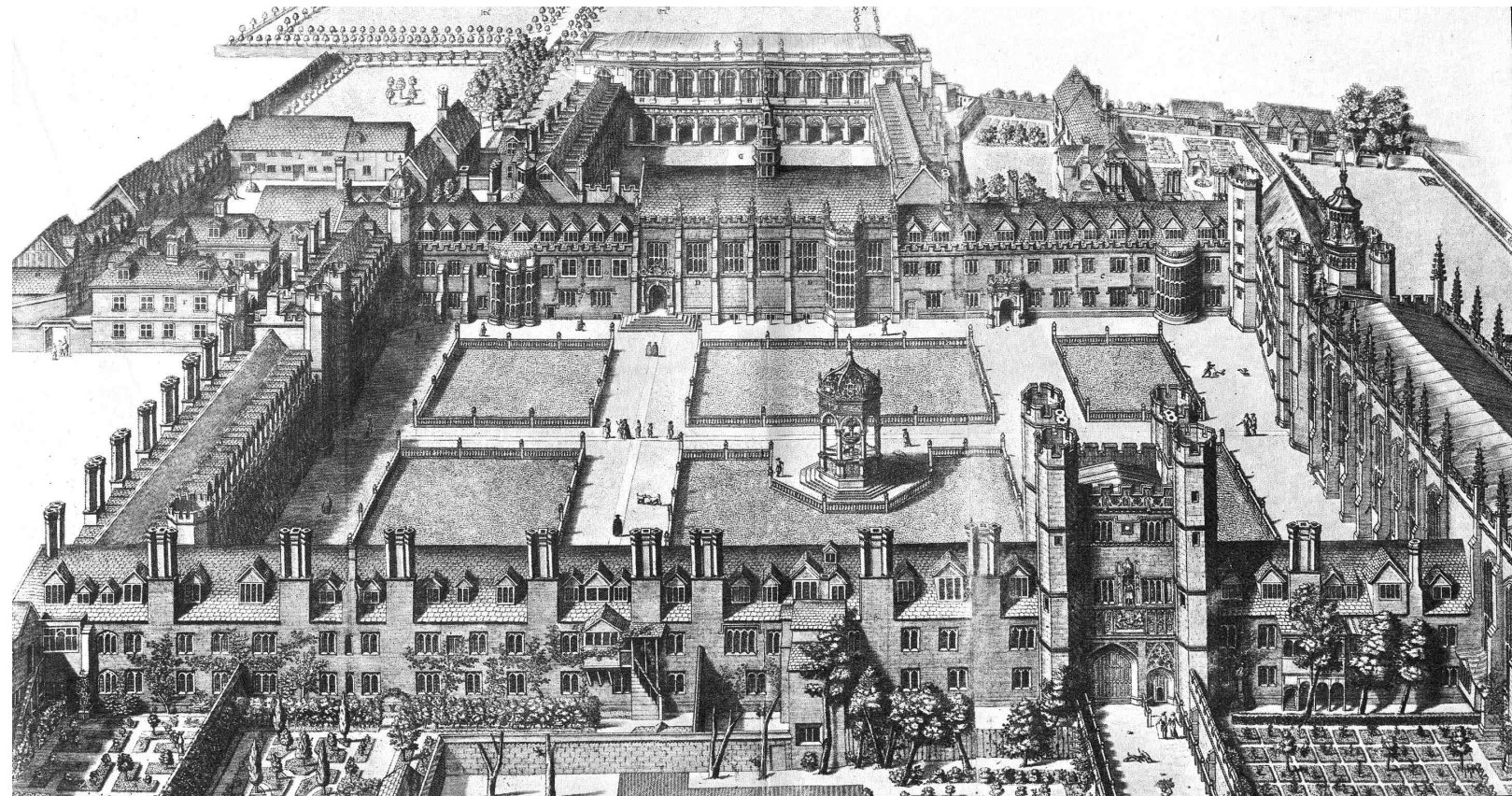


DYNAMICAL DESCRIPTION



ISAAC NEWTON

(1642 - 1727)



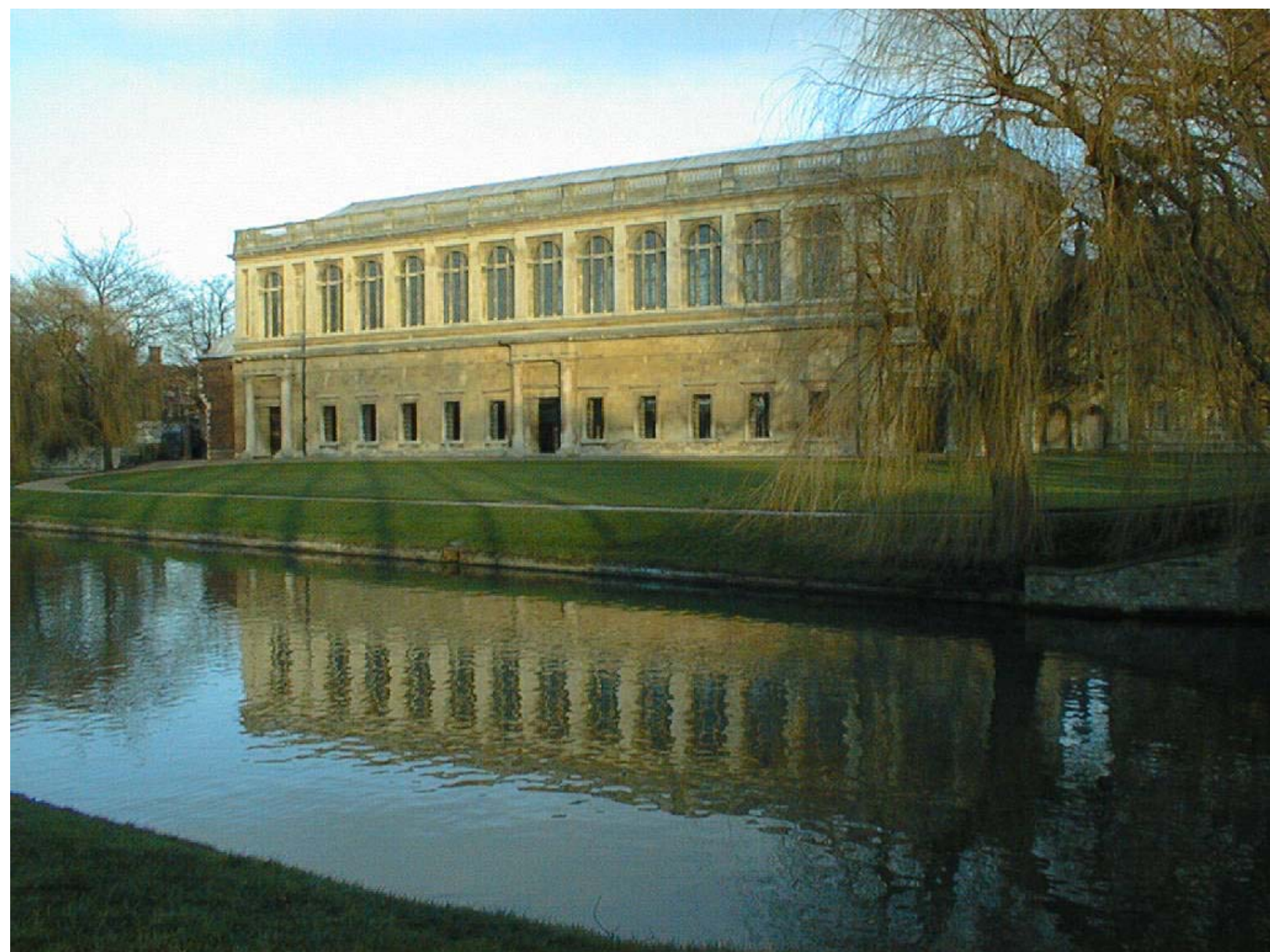
Trinity College, Cambridge



Great Gate – founded by Henry VIII in 1546



River Cam (in “backs” of Trinity)



Wren Library



Wren Library Interior



Newton

plague years 1665-1666
takes refuge in countryside

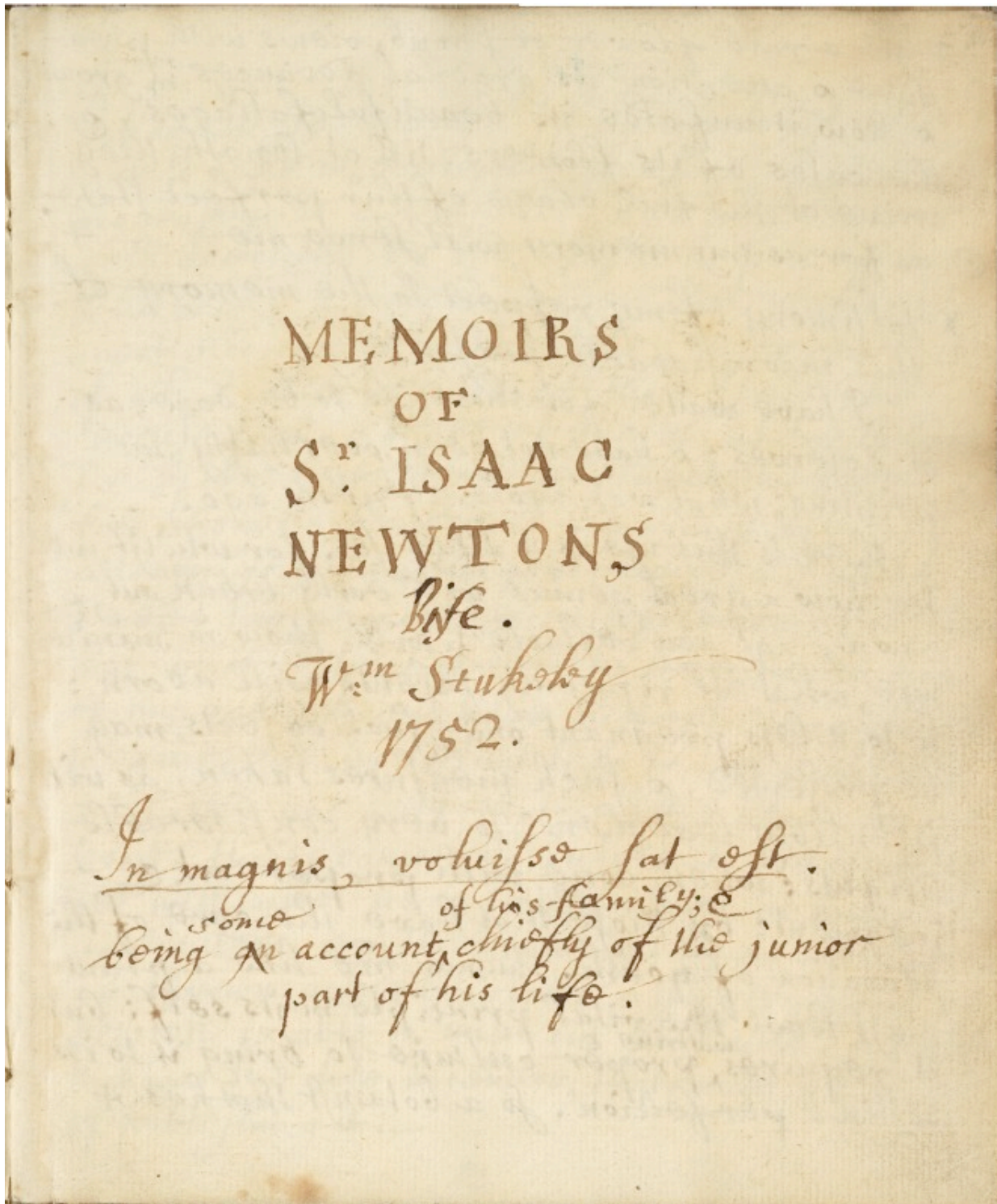


Fall of **APPLE** & **motion of MOON** : same causes ?

"In the same year I began to think of gravity extending to ye orb of the Moon ...

... and thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the Earth, and found them answer pretty nearly.

Story of discovery recounted by William Stukeley
Mémoires of Newton's life 1752



MEMOIRS
OF
S^r ISAAC
NEWTONS
Life.

W^m Stukeley
1752.

*In magnis, voluisse sat est.
being some of his family; &
an account, chiefly of the junior
part of his life.*

there; & a few more whom he knew.

15

after dinner, the weather being warm, we went into the garden, & drank tea under the shade of some apple-trees; only he, & my self. amidst other discourse, he told me, he was just in the same simalton, as when formerly, the notion of gravitation came into his mind. why sh. that apple always descend perpendicularly to the ground, thought he to himself; occasioned by the fall of an apple, as he sat in a contemplative mood. why sh. it not go sideways, or upwards? but constantly to the earths center? assuredly, the reason is, that the earth draws it. there must be a drawing power in matter. & the sum of the drawing power in the matter of the earth must be in the earths center, not in any side of the earth. therefore does this apple fall perpendicularly, or toward the center. if matter thus draws matter; it must be in proportion of its quantity. therefore the apple draws the earth, as well as the earth draws the apple.

& thus by degrees, he began to apply this property of gravitation to the motion of the earth, & of the heavenly bodies: to consider their distances, their magnitudes, their periodical revolutions: to find out, that this property, conjointly

“after dinner, the weather being warm, we went into the garden, & drank thea under the shade of some appletrees,



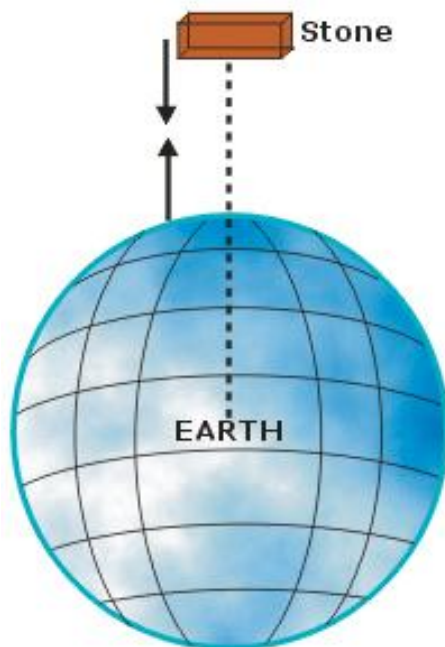
he told me, he was just in the same situation, as when formerly, the notion of gravitation came into his mind.

“why should that apple always descend perpendicularly to the ground,” thought he to him self



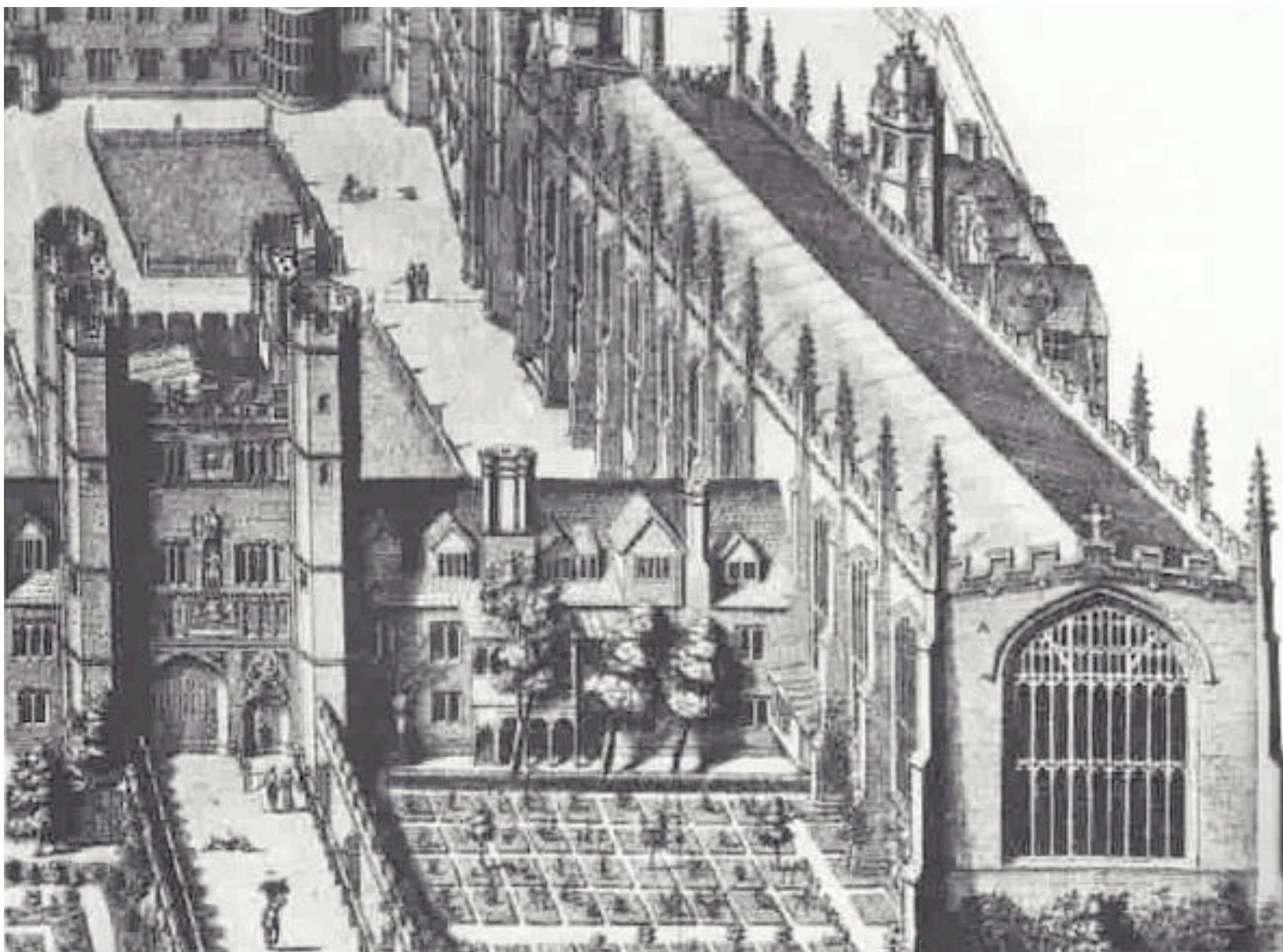
... the reason is, that the earth draws it. There must be a drawing power in matter.

... if matter thus draws matter; it must be in proportion of its quantity. therefore the apple draws the earth, as well as the earth draws the



apple.”

Trinity College Cambridge





Apple tree in front of Newton's window



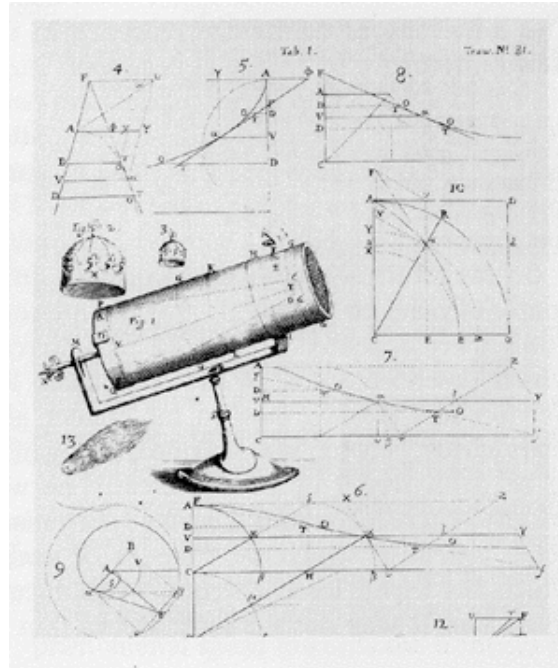
Trinity College Chapel, Great Court, fountain



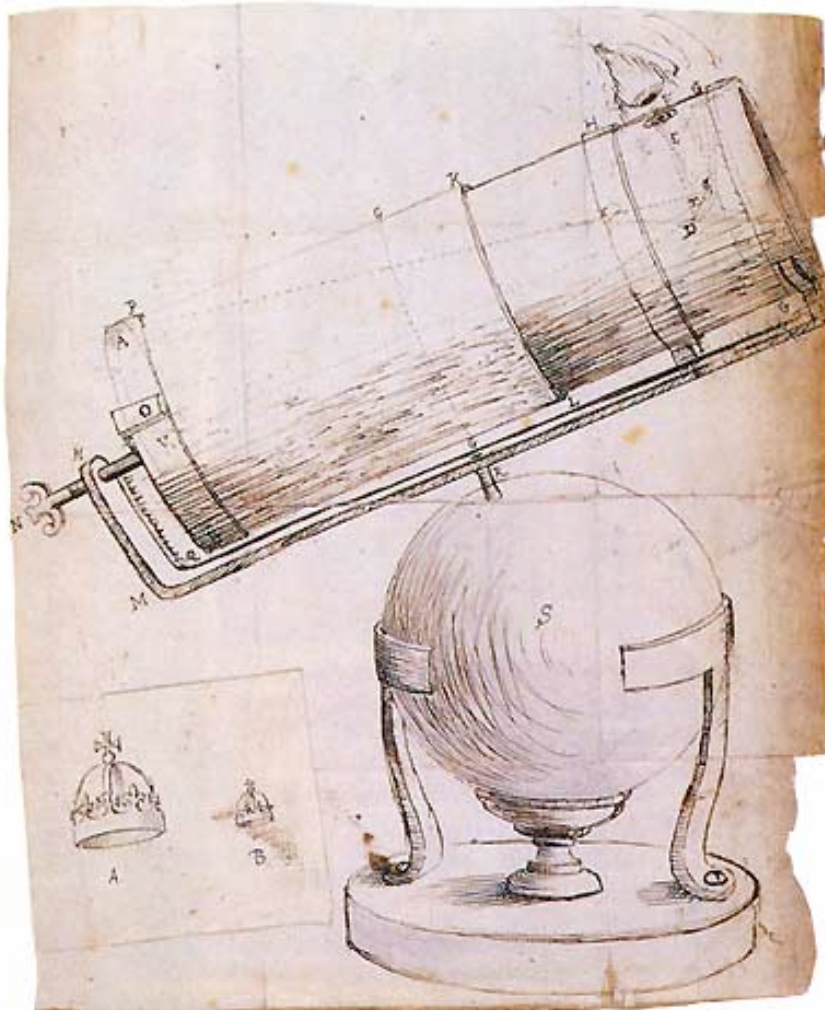
Trinity Fellow's Green

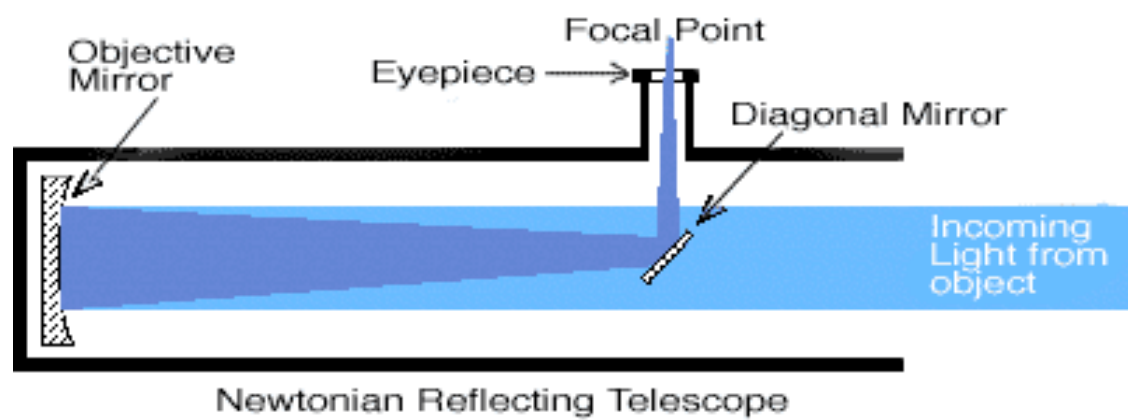


1671 Newton invents



mirror telescope





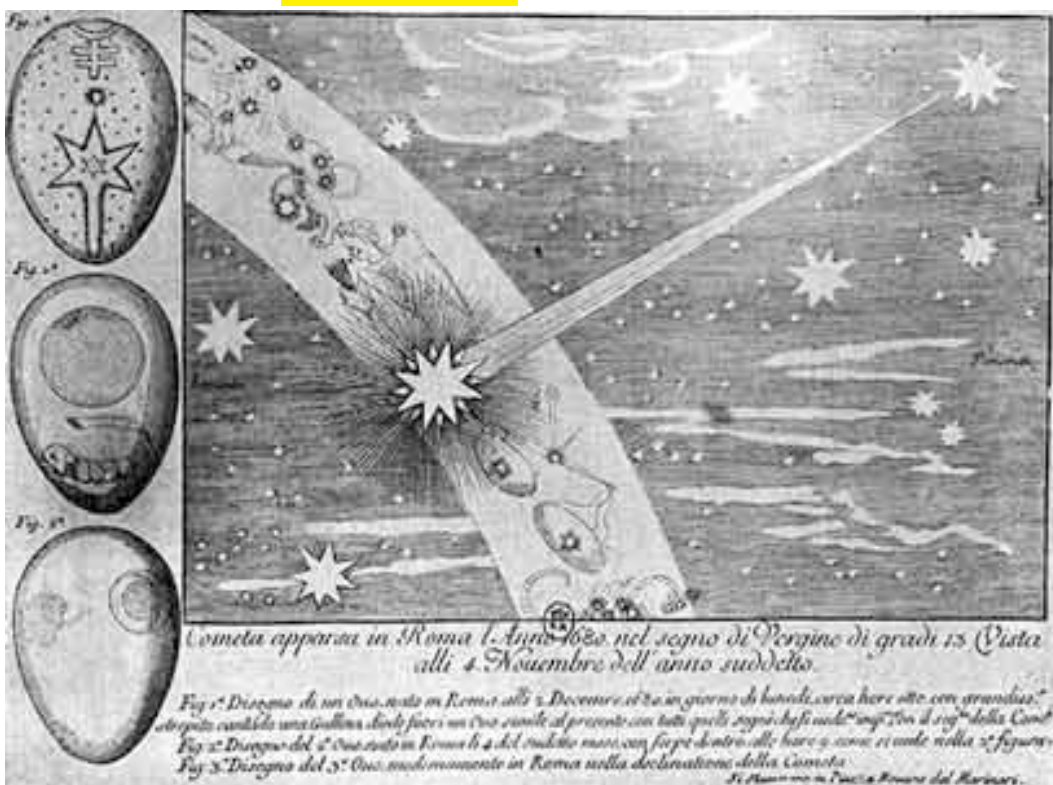


Newton's telescope (replica)



1680

Comet





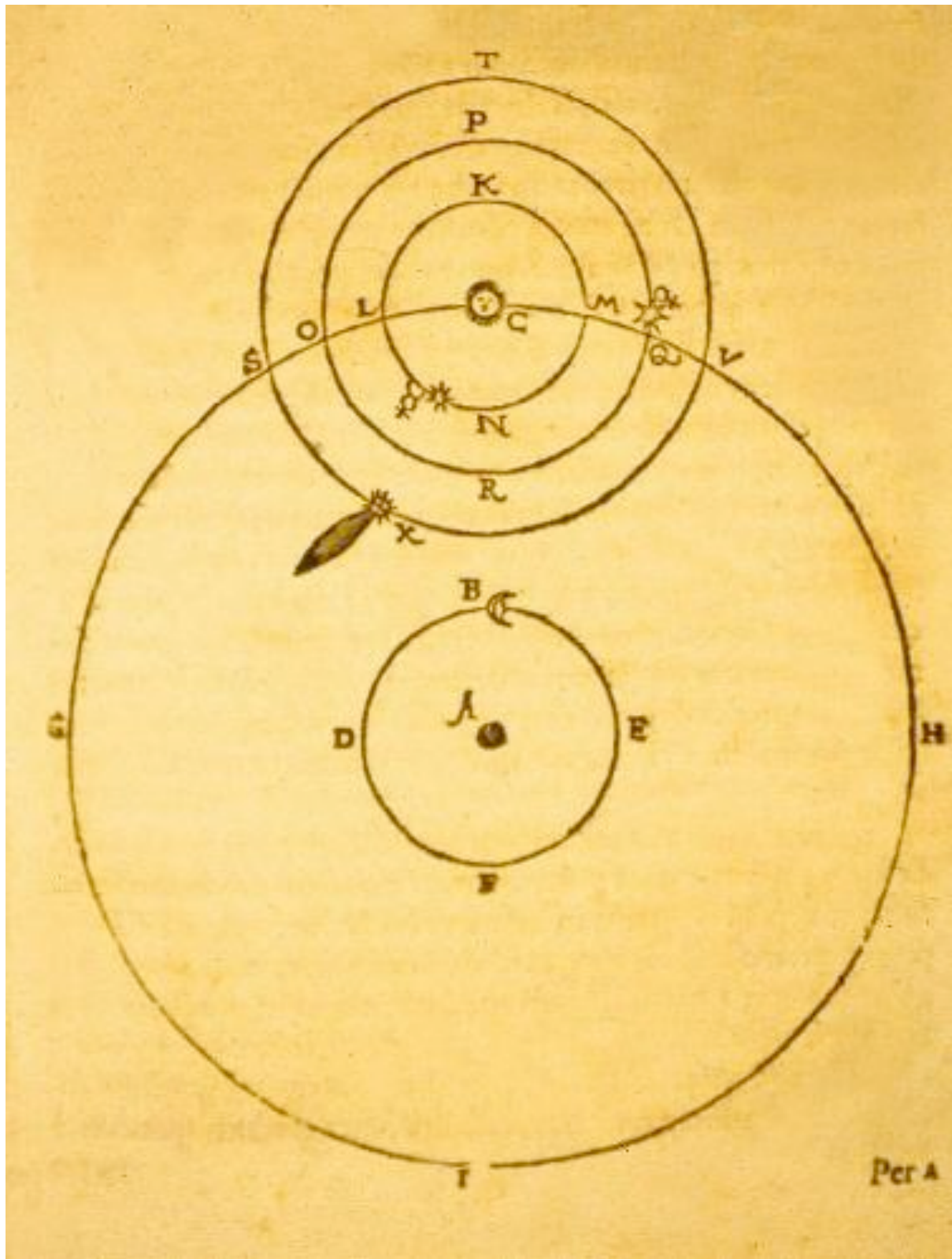
Edmund Halley

what is the form of the comet's trajectory ?

– before Kepler : disagreement

Aristoteles, Galilei: atmospheric phenomenon.

- Tycho de Brahe 1577



believes orbit is circular



1607 Kepler



Harriot

Longomontanus



observe "Halley's comet"

Kepler 1609 Mars observations \rightsquigarrow planets follow elliptic trajectories. For comets ????

1618 appears new comet.



1619 Kepler : straight trajectory

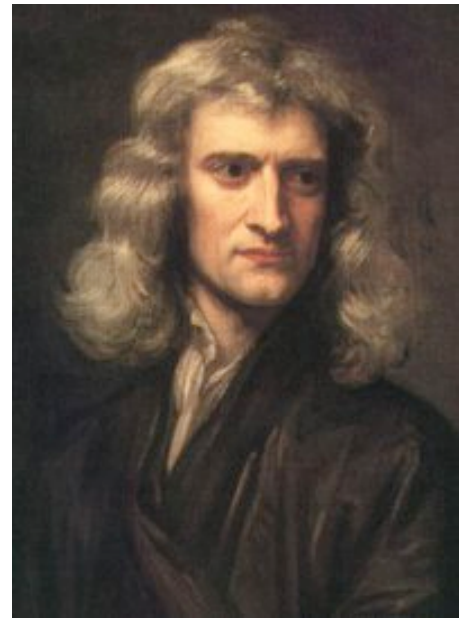


atmospheric — circular — straight ???

1684 : Halley visits Cambridge. Newton: “has resolved the pb of planetary motion, but mis-



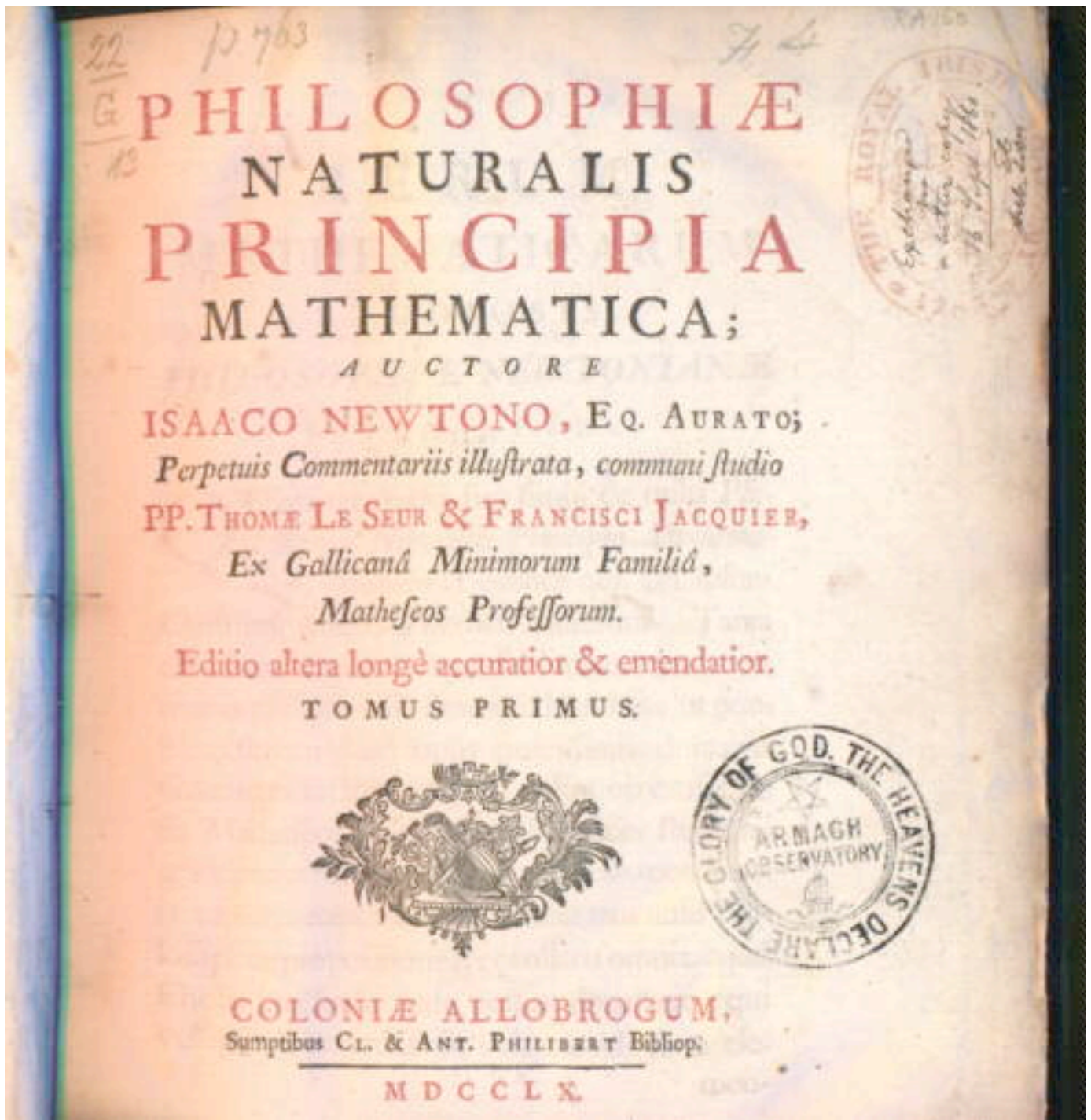
placed his notes ”



November 1684 : Newton

sends 9 pages in latin to Halley (asking him not to make it public). Continues to work out details.

1687 “Principia...”



LAW OF UNIVERSAL GRAVITATION deduced geometrically from empirical laws of Kepler.

*I deduced that the forces wch keep the Planets in their Orbs must **reciprocally as the squares of their distances** from the centres about wch they revolve*

$$F \sim \frac{1}{r^2}$$

Also studied by **Hooke** (no picture !) **Halley**

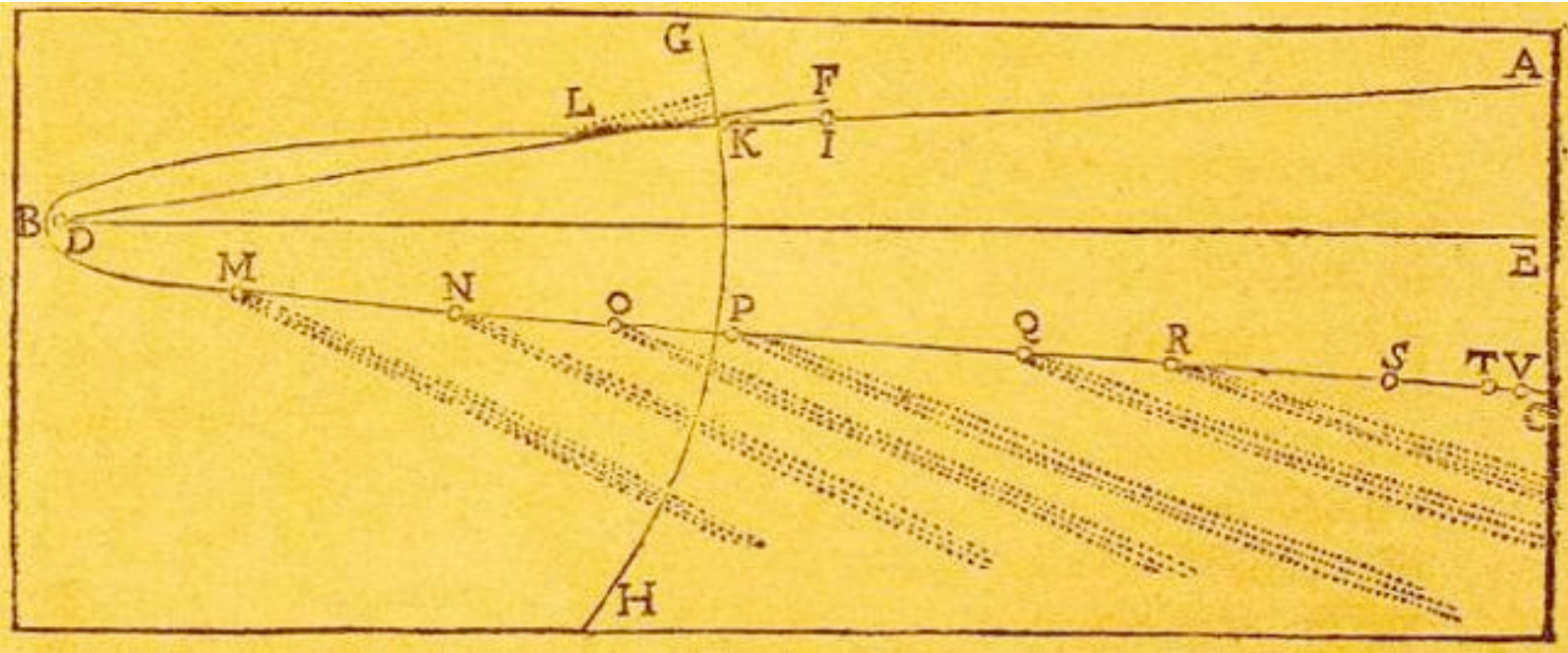


Wren



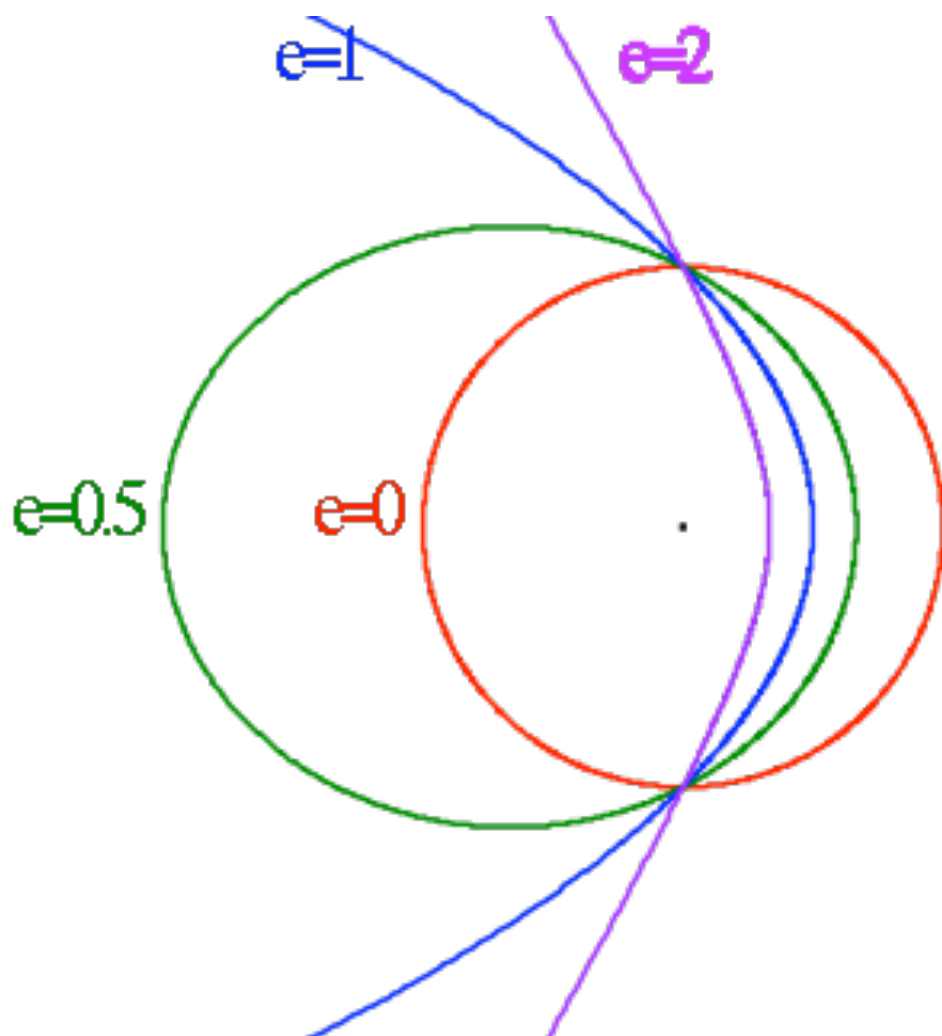
Huygens

1687 Principia : shows that the trajectory of the 1680' comet is a parabola

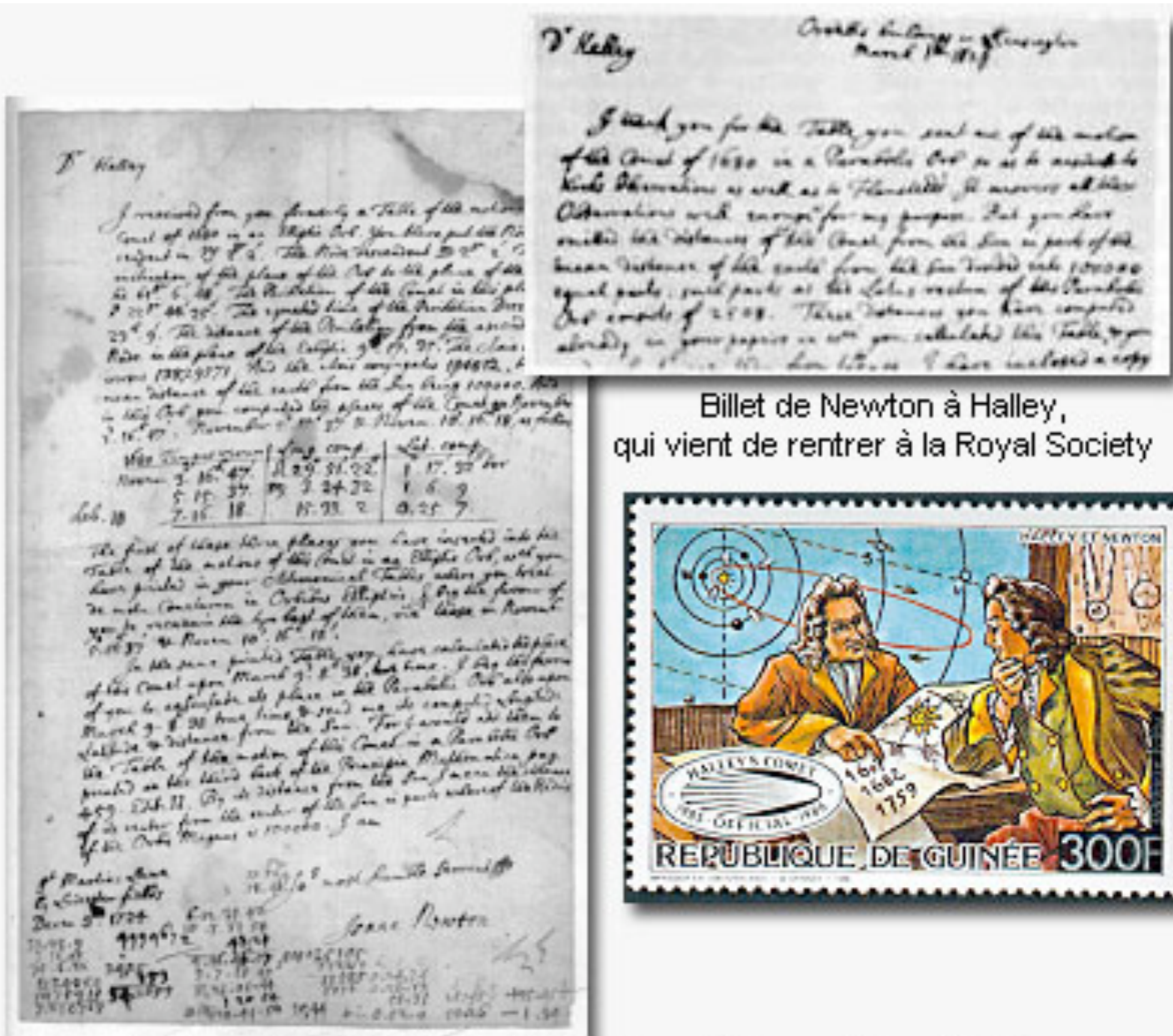


Newton proves that all trajectories are conic sections, with the Sun in their focus. Forme depends on the excentricity e

- $e = 0$ circle
- $0 < e < 1$ ellipses
- $e = 1$ parabola
- $e > 1$ hyperbola



Halley continues to study the “comet of 1682”



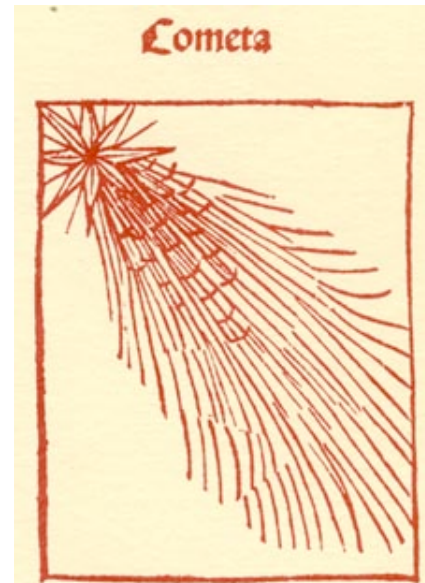
Billet de Newton à Halley, qui vient de rentrer à la Royal Society

Lettre écrite par Isaac Newton le 3 Décembre 1724 pour Edmond Halley, rapportant des observations faites sur une comète en 1680.

**MOTUM COMETARUM IN ORBE PARABOLICO
ELEMENTA ASTRONOMICA.**

Cometa Anni.	Nodus Ascend.				Inclin. Orbitæ.				Perihelium.				Distantia Perihelii à Sole.		Logarithmus Distantiæ Pe- riheliæ à Sole.		Logarithmus Medii Motus Diurni.		Temp. Equat. Perihel.			Perihel. à Nudo.			
	°	'	"		°	'	"		°	'	"				D.	H.	'	°	'	"					
1337	II	24	21	0	32	11	0	♂	7	59	0	40666	9 609236	0 546274	Junis 2	6	25	46	22	0	Retrog.				
1472	W	11	46	20	5	20	0	♂	15	33	30	54273	9 734584	0 358252	Feb. 28	22	23	123	47	10	Retrog.				
1531	♂	19	25	0	17	56	0	☿	1	39	0	56700	9 753583	0 329754	Aug. 24	21	18	107	46	0	Retrog.				
1532	II	20	27	0	32	36	0	♂	21	7	0	50910	9 706803	0 399924	Oct. 19	22	12	30	40	0	Direct.				
1556	W	25	42	0	32	6	30	W	8	50	0	46390	9 666424	0 460492	Apr. 21	20	3	103	8	0	Direct.				
1577	Υ	25	52	0	74	32	45	♂	9	22	0	18342	9 263447	1 064958	Oct. 26	18	45	103	30	0	Retrog.				
1580	Υ	18	57	20	64	40	0	♂	19	5	50	59628	9 775450	0 296953	Nov. 28	15	0	90	8	30	Direct.				
1585	♂	7	42	30	6	4	0	Υ	8	51	0	109358	0 038850	9 901853	Sept. 27	19	20	28	51	30	Direct.				
1590	W	15	30	40	29	40	40	W	6	54	30	57661	9 760882	0 318805	Jan. 29	3	45	51	23	50	Retrog.				
1596	☿	12	12	30	55	12	0	W	18	16	0	51293	9 710058	0 395041	Julii 31	19	55	83	56	30	Retrog.				
1607	♂	20	21	0	17	2	0	☿	2	16	0	58680	9 768490	0 307393	Oct. 16	3	50	108	5	0	Retrog.				
1618	II	16	1	0	37	34	0	Υ	2	14	0	37975	9 579498	0 590881	Oct. 29	12	23	73	47	0	Direct.				
1652	II	28	10	0	79	28	0	Υ	28	18	40	84750	9 928140	0 067918	Nov. 2	15	40	59	51	20	Direct.				
1661	II	22	30	30	32	35	50	♂	25	58	40	44851	9 651772	0 482470	Jan. 16	23	41	33	28	10	Direct.				
1664	II	21	14	0	21	18	30	♂	10	41	25	102575	0 011044	9 943562	Nov. 24	11	52	49	27	25	Retrog.				
1665	W	18	2	0	76	5	0	II	11	54	30	10649	9 027309	1 419164	Apr. 14	5	15	156	7	30	Retrog.				
1672	W	27	30	30	83	22	10	♂	16	59	30	69739	9 843476	0 194914	Feb. 20	8	37	109	29	0	Direct.				
1677	W	26	49	10	79	3	15	♂	17	37	5	28059	9 448072	0 788020	Apr. 26	0	37	99	12	5	Retrog.				
1680	W	2	2	0	60	56	0	♂	22	39	30	00612	7 787106	3 279469	Dec. 8	0	6	9	22	30	Direct.				
1682	♂	21	16	30	17	56	0	☿	2	52	45	58328	9 765877	0 311313	Sept. 4	7	39	108	23	45	Retrog.				
1683	W	23	23	0	83	11	0	II	25	19	30	56020	9 748343	0 337614	Julii 3	2	50	87	53	30	Retrog.				
1684	♂	28	15	0	65	48	40	W	28	52	0	96015	9 982339	9 986620	Maii 29	10	16	29	23	0	Direct.				
1686	♂	20	34	40	31	21	40	II	17	0	30	32500	9 511883	0 692304	Sept. 6	14	33	86	25	50	Direct.				
1698	♂	27	44	15	11	46	0	W	0	51	15	69129	9 839660	0 200638	Oct. 8	16	57	3	7	0	Retrog.				

Halley's tables of observations



previous apparitions : 684

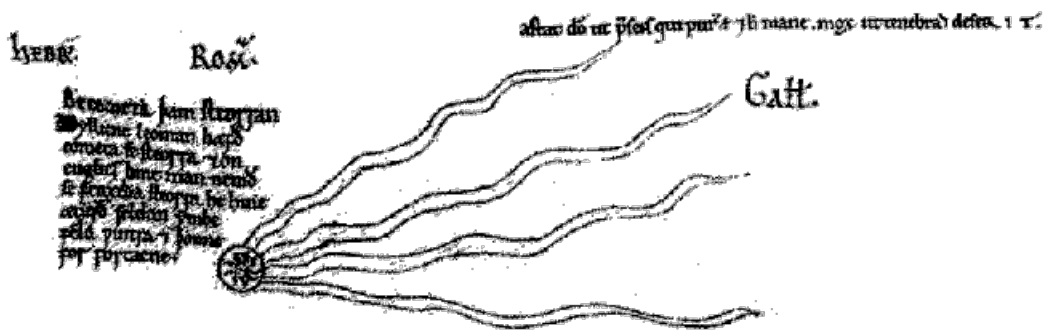


1066

Bayeux Tapestry [conquest of Brittany by the normans] [also seen in China !]

1038 Byzantine princesse **Anna Comnenos** re-
ports

1145 Canterbury



1301

Giotto

YOU ARE WELCOME TO CONTACT ME:

email: horvathy@univ-tours.fr