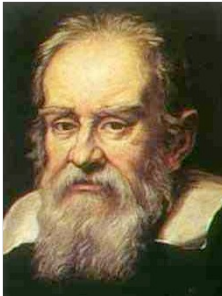


# 14. Galileo's Telescope

- *The Starry Messenger*  
(*Sidereus Nuncius*) (1610)

- 1608. Dutch lens-makers Hans Lippershey and Jacob Metius apply independently for patents on a device for "seeing faraway things as though nearby". (Sacharias Janssen also in possession of device.) 3×-4× magnification.
- 1609. Galileo constructs higher-powered versions of "spyglass". Uses 20×-magnification device to conduct observations reported in *Sidereus Nuncius*.



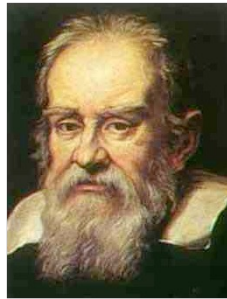
Galileo Galilei  
(1564-1642)



## Galileo's Observations

### (1) Moon's surface:

"I have been led to the opinion and conviction that the surface of the moon is not smooth, uniform, and precisely spherical as a great number of philosophers believe it (and the other heavenly bodies) to be, but is uneven, rough, and full of cavities and prominences, being not unlike the face of the earth, relieved by chains of mountains and deep valleys."

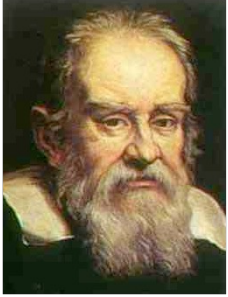


*Engravings based on sketches.*

### Implications:

- Celestial realm is not perfect.
- Earth is not unique.

## (2) Earth shine on moon:



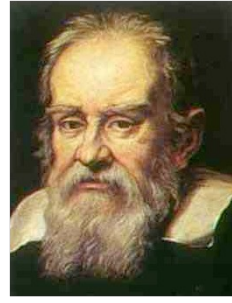
"When the moon is not far from the sun...its globe offers itself to view not only on the side where it is adorned with shining horns, but a certain light is also seen to mark out the periphery of the dark part which faces away from the sun. If this kind of light were the moon's own, or were contributed by the stars, the moon would retain it and would display it particularly during an eclipse... This is contradicted by experience... It is likewise unthinkable that this light should depend upon the sun's rays penetrating the thick solid mass of the moon... Surely we must assert that the lunar body (or any other dark and sunless orb) is illuminated by the earth."

### Implication:

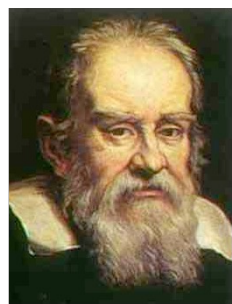
- Earth is not unique. (It reflects light from the sun like the planets.)

(3) Vastly many more stars, all no more brighter through telescope than if viewed with naked eye.

"The stars, whether fixed or wandering, appear not to be enlarged by the telescope in the same porportion as that in which it magnifies other objects... Now in addition to stars of the sixth magnitude, a host of other stars are perceived through the telescope which escape the naked eye; these are so numerous as almost to surpass belief."



The Belt and Sword of Orion



"...to the three stars in the Belt of Orion and the six in the Sword which were previously known, I have added eighty adjacent stars discovered recently..."

Implication:

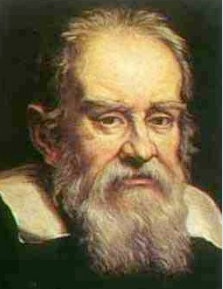
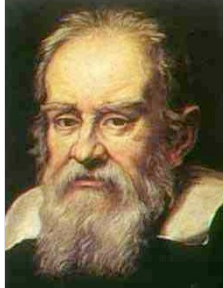
- Fixed stars may be very far away (in support of no observed stellar parallax).

(4) Four new planets that revolve around Jupiter.

"On the thirteenth of January four stars were seen by me for the first time, in this situation relative to Jupiter.



Three were westerly and one was to the east; they formed a straight line except that the middle western star departed slightly toward the north... All the stars appeared to be of the same magnitude, and though small were very bright, much brighter than fixed stars of the same size."

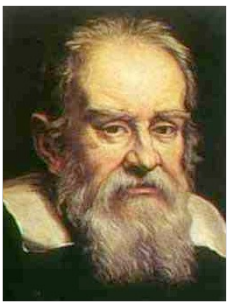


"But now we have not just one planet rotating about another while both run through a great orbit around the sun; our own eyes show us four stars which wander around Jupiter as does the moon around the earth, while all together trace out a grand revolution about the sun in the space of twelve years."

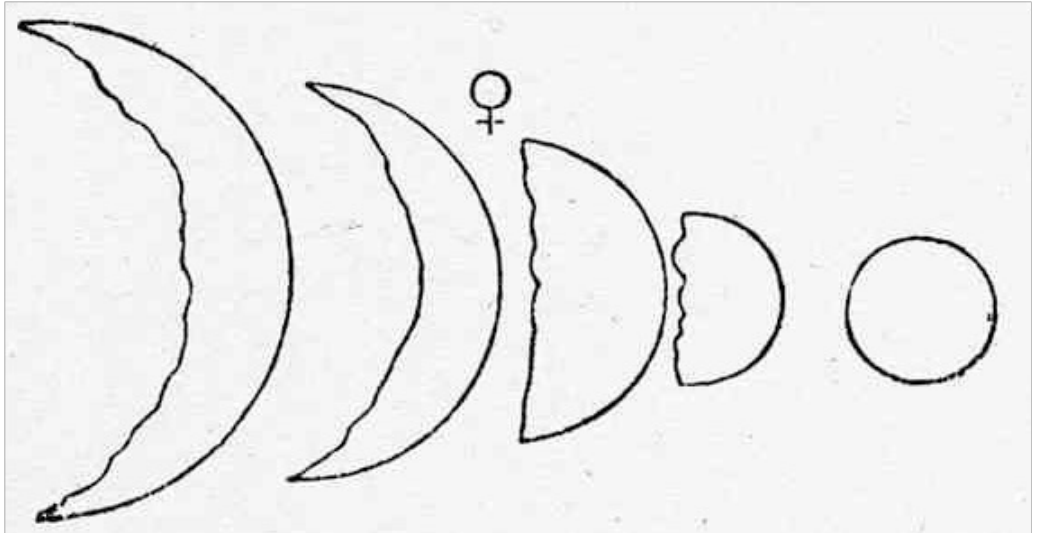
Implications:

- If "Medicean planets" can keep up with Jupiter, the moon should be able to keep up with the earth.
- The earth is not unique (it's *inferior* in number of moons to Jupiter).

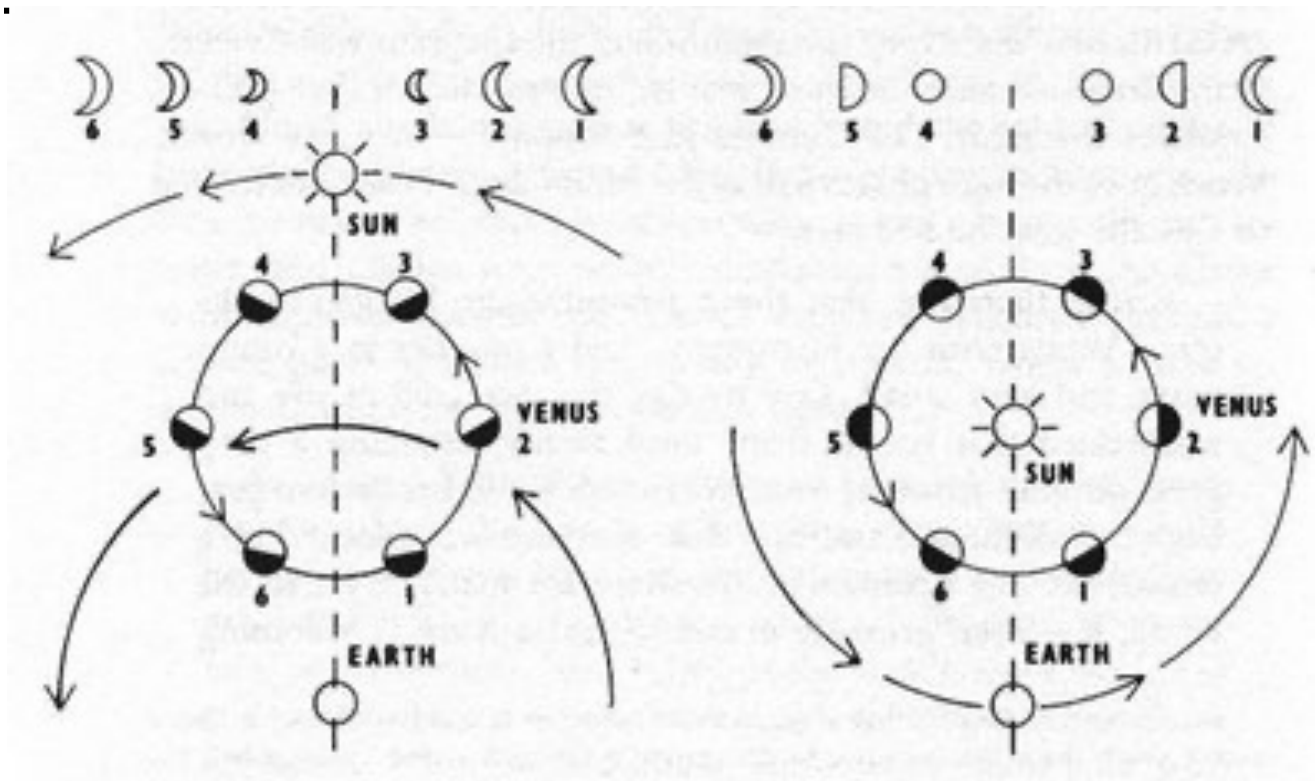
# (5) Phases of Venus (1610 Letter to Christopher Clavius).



"... when Venus began to be visible in the evening sky, I started observing it and saw that its figure was circular, though extremely small. Afterwards, I saw [Venus] growing in magnitude significantly, though always maintaining its circular shape. Approaching maximum elongation, [Venus] began to lose its circular shape on the other side from the Sun and within a few days had acquired a semicircular shape. This shape it maintained for a number of days. More precisely, it maintained [this shape] until it began to move towards the Sun, slowly abandoning the tangent. It now begins to assume a notable corniculate shape. Thus, it will continue to decrease during the period in which it remains visible in the evening sky."

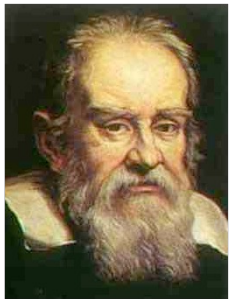
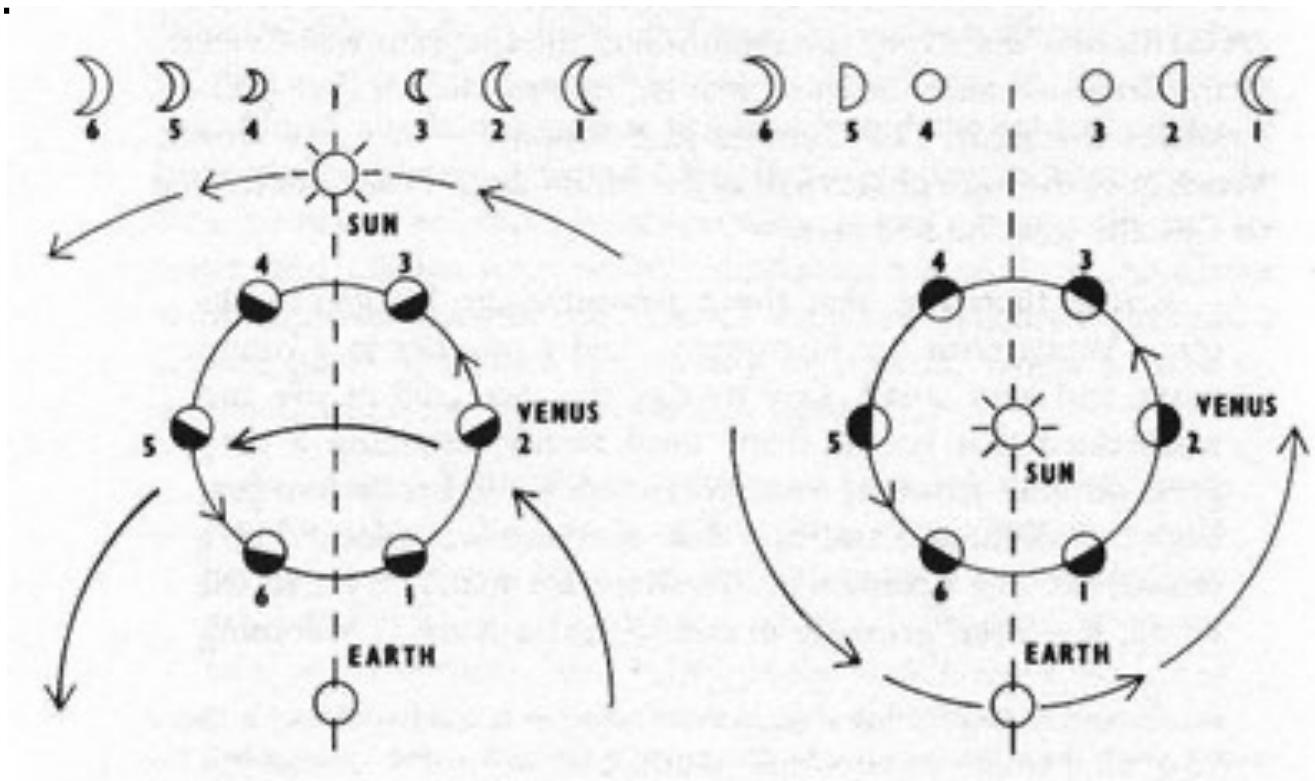


## Implications:



- In a Ptolemaic system, Venus may display phases that vary in the appropriate sizes.
- But: Such phases will *only* be crescent-shaped (as in above left) or full/gibbous, depending on whether Venus is between the Earth and the Sun, or the Sun is between the Earth and Venus.
- So: Observed *transitions* between full phase and crescent phase cannot be explained in a Ptolemaic system.

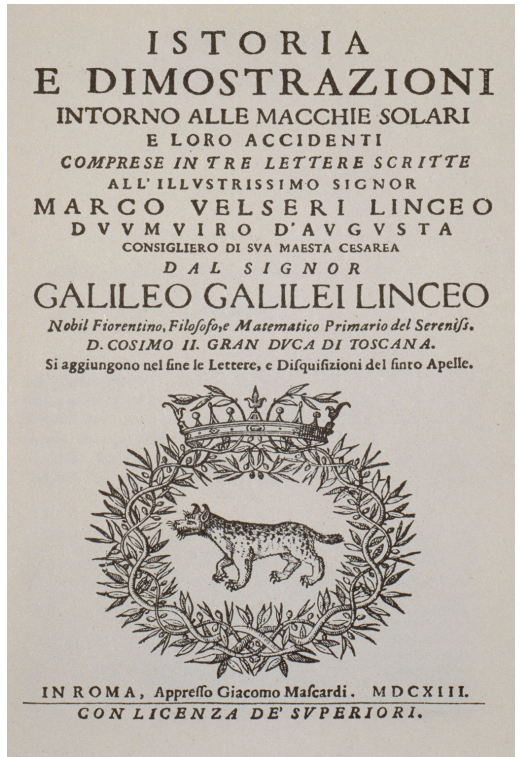
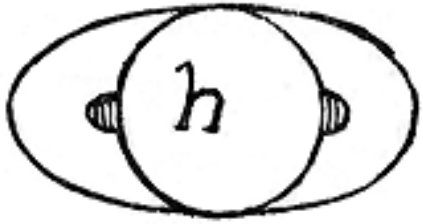
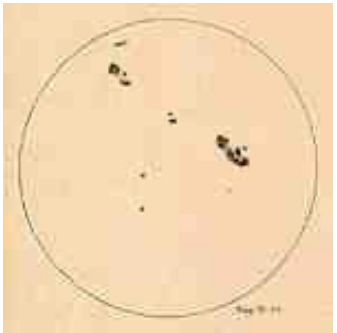
# Implications:



"We are now certain that Venus orbits the Sun, neither [revolving] below (as Ptolemy believed), where it would always show [a phase] less than one half of a circle, nor above..., since if it were above the Sun one would never observe it crescent, but always much more than one half and almost always perfectly circular."



# (6) Sunspots and Saturn's "ears" (1612, *Letters on the Sunspots*)



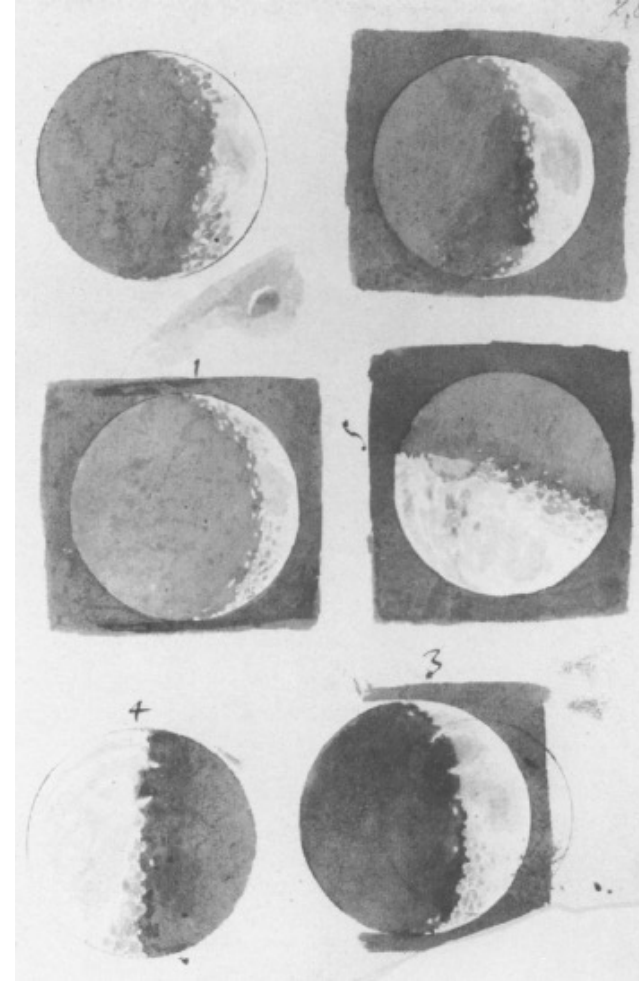
## Implications:

- Further evidence of imperfections in celestial realm.

## Is this Convincing Evidence Against the Aristotelian?

- Reliability of telescope might be questioned:
  - *Observations require some degree of interpretation.*
  - *Galileo was already committed to replacing Aristotle's theory of motion.*
- Galileo was a trained artist.
  - *Engravings in *Starry Messenger* based on inkwashes drawn in a studio after observations.*
  - *Employed Baroque painting techniques of contrast and manipulation of darks and lights to increase mutual intensities.*

"Is it preposterous to claim that these simple yet highly professional drawings belong as much to the history of art as they do to science?"\*



*Original inkwashes: half-dozen different grades of wash.*

## Is this Convincing Evidence Against the Aristotelian?

- What about the phases of Venus?
  - *Inconsistent with Ptolemaic system.*
  - *But still consistent with some geostatic variants:*

### Tychonic System

- Earth at center of cosmos *A*.
- Moon revolves about Earth at *B*.
- Sun revolves about Earth at *C*.
- Planets revolve about Sun.



*Tycho Brahe*  
(1546-1601)

