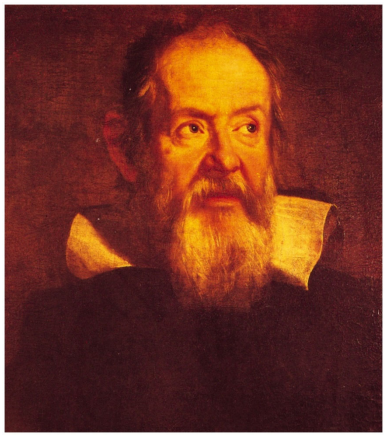
RENAISSANCE ASTRONOMY

Question

What kind of observations would conclusively prove that the Earth is in orbit around the Sun?

Galileo Galilei

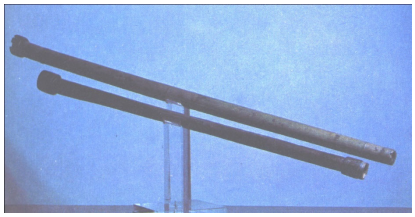


Galileo Galilei
[1564 – 1642, Italy]

Considered the Father of Modern Astronomy because **he was the first to use a telescope to observe celestial objects**. His greatest accomplishment was proving the Copernican Helio-centric Cosmology to be correct.

However, his conclusions (and style of presentation) caused a conflict with the ruling Catholic authorities.

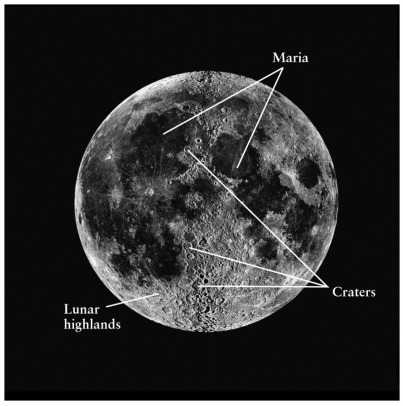
His Science – Astronomy

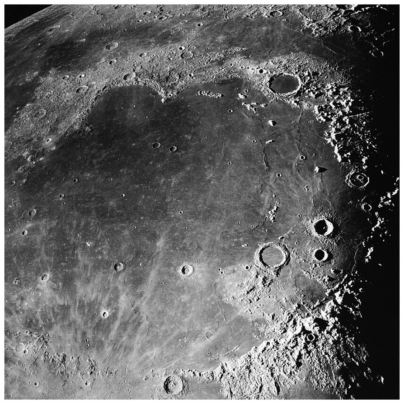


The first telescope is today credited with a Dutch lens maker by the name of **Hans Lippershey** in 1608. Galileo constructed one after hearing about it. (Padua is not far from the excellent glass manufacturers in Venice.)

Galileo's first telescope was 3X; eventually he made one as strong as 30X. Most people, including himself, saw the telescope's potential for terrestrial use, but he was the first to use a telescope to study the heavens.

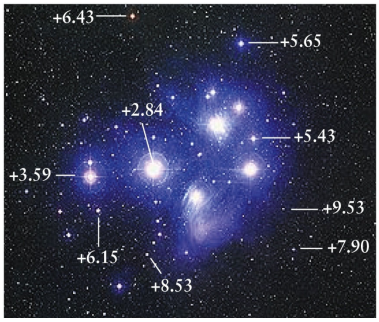
1. Rugged Lunar Surface

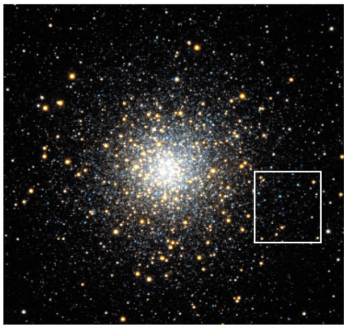




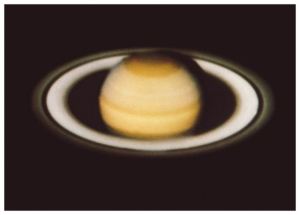
2. Unseen Stars Become Visible

3. Nebulous Blurs are Resolved

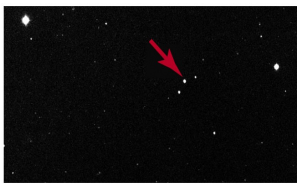




4. Other Observations



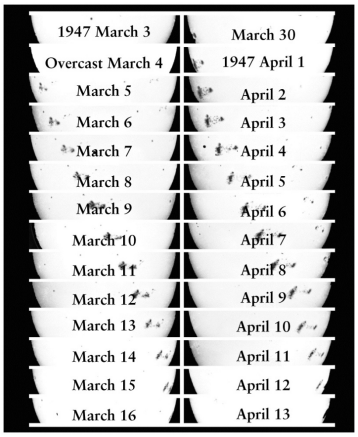
Saturn had "ears" – he could not resolve the ring system because his telescope was too small and had too low a resolution.



May have actually seen Neptune. An object is plotted in the right position on one of his star charts.

5. Sun has Spots and Rotates

Jesuit Scheiner

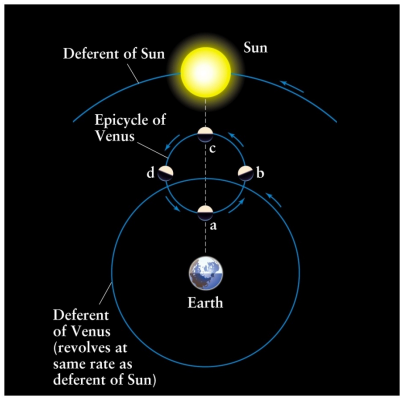


6. Moons of Jupiter

Discovered the four largest, brightest moons of Jupiter. He wanted to name them after the four Medici brothers (and would then hopefully get a great court position at Florence), but other astronomers were against it. The names are **Io, Europa, Ganymede, and Callisto**.

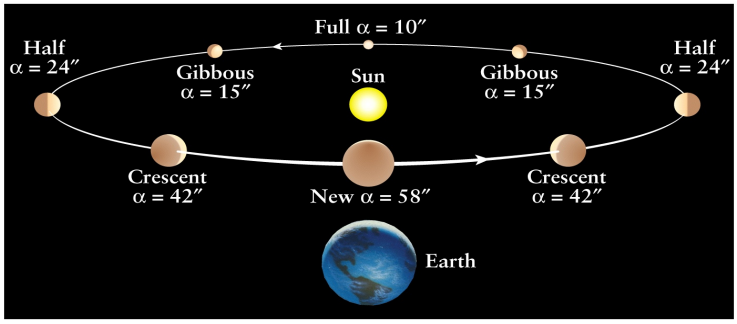
The importance of this discovery was it showed that some heavenly bodies did not orbit around the Earth. **However, it did not conclusively prove the Earth orbits the Sun.**

7. Phases of Venus



If the Solar System was Geocentric, then an observer on the Earth would only be able to see a small crescent phase of Venus and Mercury.

7. Phases of Venus



If the Solar System was Heliocentric, then an observer on the Earth would be able to **see all phases** of Venus and Mercury, and the sizes of the disks would change substantially because of different separations.

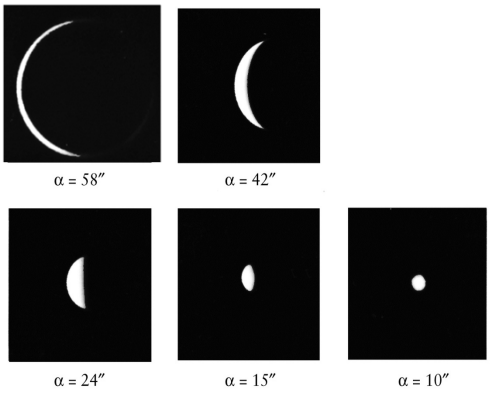
7. Phases of Venus

Interestingly, a former student Benedetto Castelli wrote on December 5, 1610, to Galileo and noted that telescopic observations of Venus could help distinguish between the heliocentric and geocentric possibilities.

A few days later, Galileo sent an anagram – cryptic message – to the Medician Secretary about HIS observations of the phases of Venus.

Venus is like a bowl of vanilla gelato.

7. Phases of Venus



The importance of this discovery was it showed Venus did not orbit about the Earth but about the Sun.

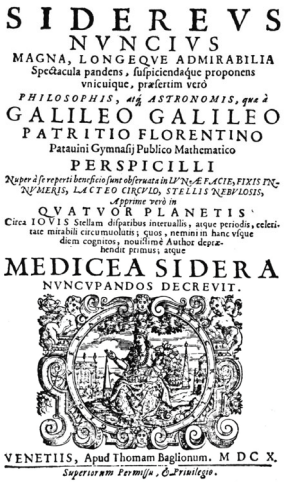
It conclusively proved one planet orbited the Sun according to Copernicus.

But what about the Earth?

Recap of Observations

1. Lunar surface shows craters, mountains, and seas.
2. Unseen (faint) stars become visible.
3. Nebulous blurs (Pleiades, Praesepe) are resolved into stars.
4. Saturn has ears – could not resolve rings. May have seen Neptune.
5. Sun has spots (not perfect) and the sun rotated.
6. **Jupiter has 4 moons** with periods ranging from 2 to 17 days. (This showed that a center of motion could itself be in motion.)
7. **Venus goes through all phases**. (This observation supports the Copernican heliocentric model.)

Starry Messenger


SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperta 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 circumuolatis; quos, neminem in hanc vsque
diem cognitos, nouissimè Author deprę-
hendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

Galileo's observations were published around 1610 in the *Sidereus Nuncius (The Starry Messenger).*

It was dedicated to the Grand Duke Cosimo II de Medici, who subsequently appointed Galileo to a secure government (court) position in Florence (Tuscany).

The four moons of Jupiter are the *Medicea Sidera* (Medician Stars)

Fight Against Copernicanism

The Catholic Church decided in 1615 that

Immobility of the Sun – Heretical
Mobility of the Earth – just wrong

Prohibit *De Revolutionibus*

But,

1. Copernicus' book was very important and useful for calculations of the calendar and of Easter's dates.

2. Cardinal Maffeo Barberini withstood Pope Paul V openly against "declaring Copernicus contrary to the faith."

3. *De Revolutionibus* was not Prohibited.

Reign in Galileo

For Galileo, he was called before Cardinal Barberini and Cardinal Robert Bellarmine and he was told not to speak out forcefully in favor of Copernicus.

Galileo said: OK

But later he heard rumors, so Galileo got a letter from Cardinal B stating "he has not been abjured or punished."

Proving the Heliocentric View

It was one thing to argue that the heliocentric arrangement is compatible with the Book of Scripture and quite another to prove that the Book of Nature speaks unmistakably in favor of Copernicus. To understand this part of the controversy it is necessary to keep in mind the two forms of Aristotelian logic: induction and deduction.

This section is from Owen Gingerich's *The Galileo Affair* in the book The Great Copernicus Chase.

Induction

Induction is the process of drawing general conclusions from particular instances; it is, I think, the basic process whereby learning takes place. Consider the reproduction of birds: chickens lay eggs, robins lay eggs, ostriches lay eggs and so on, and thus we generalize that all birds reproduce by laying eggs. We have not proved this conclusion, however, since there is always the possibility that a counterexample will be found. For this reason inductive reasoning, as all the scholastic philosophers of Galileo's time knew, cannot lead to indubitable truth.

Deduction

Deduction is another matter. Given true premises, a conclusion reached by valid deduction must be rigorously true. Consider this syllogism:

(A) If it is raining, the streets are wet.
(B) It is raining.
(C) Therefore the streets are wet.

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Now consider the converse:

(A) If it is raining, the streets are wet.
(B) The streets are wet.
(C) Therefore it is raining.

To students of logic this procedure of confirming the consequent was a well-known fallacy. After all, the street could be wet for other reasons: the winter snow could be melting, the street-cleaning department might be out in force or the Lippizaner horses might have been on parade.

Deduction

How does this logical analysis apply to Galileo's defense of Copernicanism? Consider this syllogism:

(A) If the planetary system is heliocentric, Venus will show phases.
(B) The system is heliocentric.
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True enough, but this was not the form of Galileo's argument. He had exchanged the second premise and the conclusion:

(A) If the planetary system is heliocentric, Venus will show phases.
(B) Venus shows phases.
(C) Therefore the planetary system is heliocentric.

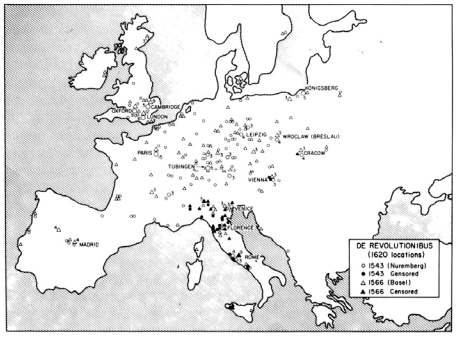
Clearly Galileo had committed an elementary blunder of logic

Deduction

"Galileo's process of reasoning was similar to induction but more sophisticated. It was what is now called the hypothetico-deductive method: **the testing of a hypothetical model**, which attains ever more convincing likelihood as it passes each test successfully.

Today it is not the word ***truth*** but the word ***model*** that decorates the pages of scientific journals."

Ultimate Conflict



Galileo had accumulated a great deal of evidence to support the Copernican system. By the decree of 1616, he was forbidden to "hold or defend" the odious hypothesis, but he still hoped to convert his countrymen to the heliocentric view.

Galileo prevailed upon his long-time friend Pope Urban VIII, to allow him to publish a book that explained fully all arguments for and against the Copernican system, not for the purpose of extolling it, but merely to examine it.

The Dialogue

In 1632 he published *The Dialogue of the Two Great World Systems* in Italian. But he did not follow the instructions to be impartial!

The three characters were

- Simplicio
- Salviati
- Sagredo

The Dialogue

Although the Pope was furious for being made to look like a fool, there were two issues in Galileo's favor:

Copernicus's doctrine was never declared heretical.

The *Dialogue* was given a license from the censors.

The Dialogue

Galileo was brought before the Inquisition in 1633.

Inquisitors produced a document from 1616 claiming Galileo had been told not to teach or defend Copernicus in any way.

However, the document was not signed and the author (Cardinal Bellarmine) was dead.

Then Galileo produced the letter he had requested.

The Dialogue

Galileo thought there would be a plea deal. Instead, the Inquisition threatened him with torture.

He spent his last ten years in house confinement.

The Bible tells one **"How to go to Heaven – not how the Heavens go."**