RENAISSANCE ASTRONOMY

Question

What kind of observations would conclusively prove that the Earth is in orbit around the Sun?
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 Heliocentric 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 (including himself) saw the telescope’s potential for terrestrial use, but he was the first to really use a telescope to study the heavens.
1. Unseen Stars Become Visible

2. Nebulous Blurs are Resolved
3. Rugged Lunar Surface

4. Sun has Spots and Rotates
5. Moons of Jupiter

Discovered the four largest, brightest moons of Jupiter. Wanted to name them after the four Medici brothers, 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 that the Earth orbited the Sun.

6. 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.
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.

The importance of this discovery was it showed that 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?
7. 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.

Recap of Observations

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

Galileo’s observations were published 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.

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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.
(C) Therefore Venus will show phases.
Deduction

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

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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 continually 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.

He 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!

Galileo was brought before the Inquisition and was forced to plead guilty. He spent his last ten years in confinement at his house.

The Bible tells one “How to go to Heaven – not how the Heavens go.”