

The aim of every artist is to arrest motion, which is life, by artificial means and hold it fixed so that a hundred years later, when a stranger looks at it, it moves again since it is life.

William Faulkner

Eppur Si Muove (And yet it moves)

Hi everyone In this module, we'll continue our investigation into the revolution that took place in astronomy, and in society in general, that we are not the center of the solar system/universe.

We've met the character who had the great idea, Nicholas Copernicus. We met a great observer, Tycho. We met somebody who could make sense of all that data, Kepler. But this was all happening in a rarefied intellectual environment. For any good idea to reach the masses, you need a public relations person. You need to get it out there to the people and let them know what's going on. And in this revolution, the PR guy was Galileo Galilei.



Credit: Museum of the History of Science, Florence

Credit: Galileo Project, public domain



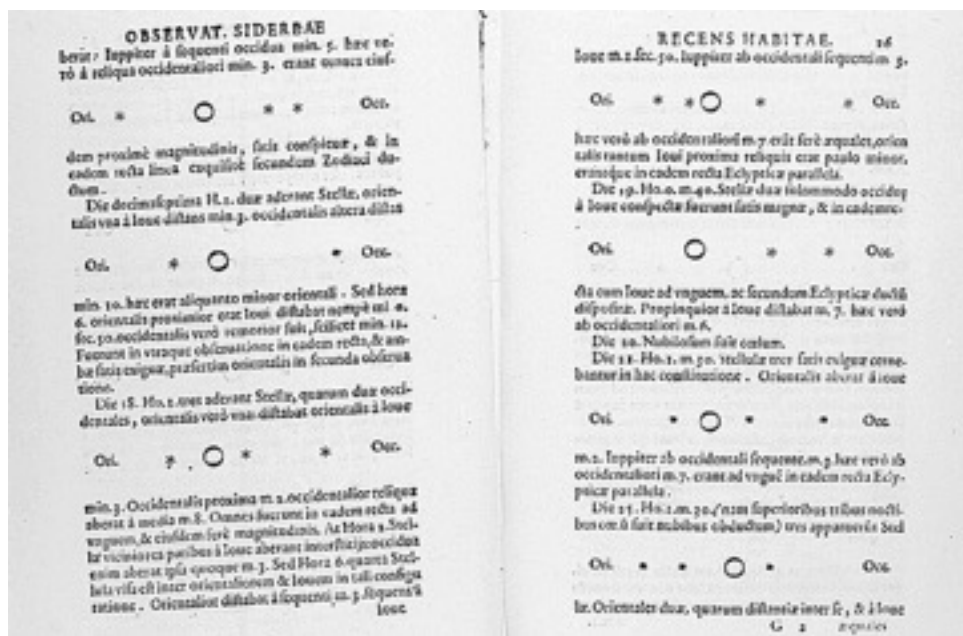
Above is an image of a young Galileo and his first telescope. Telescopes were originally invented for commerce, not for viewing the night sky. The idea is that you would take your telescope, go up to a high point in a city, and you'd look out over the sea. You could see when the ships were just coming over the horizon. When you saw the ships coming over the horizon, that was the right time to go out and get your crew that was going to unload the ship, or load the ship, whatever the case may be. It was a lot more efficient, i.e. it cost less money, because you didn't have to have your crew hanging out, waiting around. You didn't know where the ship was until you can make a visual line of sight. So the telescope was really invented to aid economies.



Credit: Yale University Library

Galileo built one of the very first telescopes and was the first to aim it not at ships, but at the skies. He created an absolute public sensation in 1610 when he published what he saw with his telescope in a book that he called Sidereus Nuncius, or translated, Starry Messenger. What would you see if you were the first person in history to look at the night sky through a telescope? What would you look at? What would you see?

Well, one of the first things he did is he looked at the Sun. Don't you do that. Bad idea. Don't look at the Sun directly with a telescope, because you'll damage your vision. But Galileo saw sunspots on the Sun, and he saw mountains on the Moon. The image above from Starry Messenger shows these strange circular indentations. Galileo didn't know what these were. Today we know that they're impact craters.



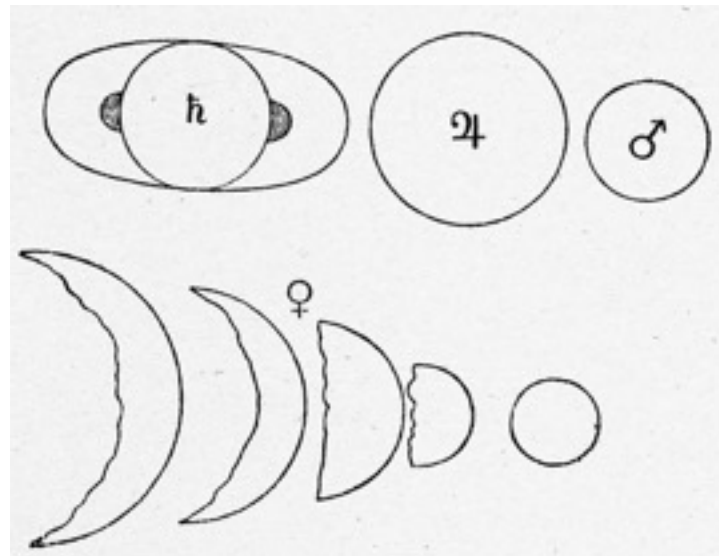
Credit: Trinity College, Cambridge

His point of showing this -- remember, he's on a PR mission here-- is to suggest that the heavenly bodies were not perfect. The Sun had zits and the Moon had mountains. And therefore, maybe, elliptical orbits with the Sun at one focus were not so objectionable.

And he discovered the moons of Jupiter. Io, Europa, Ganymede, and Callisto. For the first time, there is another center of motion in the universe. It's not just stuff going around the Earth or stuff going around the Sun, as the debate was, but here was another center of motion - moons orbiting Jupiter!

In the image above from *Starry Messenger*, Jupiter is the large circle, and he's got the four moons as asterisks. It took him a little while to figure out that these asterisks were actually orbiting Jupiter, as opposed to four independent pair of lights near Jupiter.

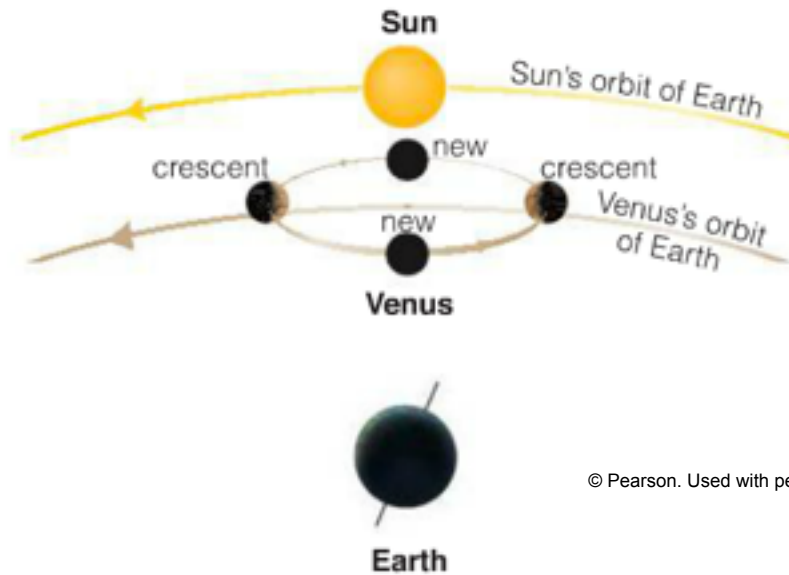
This is important in his PR case, because it showed that things could orbit one another without them flying off. The standard argument was that if the Earth is going around the Sun, the Moon would go flying off somewhere. The Moon wouldn't stay. But here was an example where you had objects orbiting another center of motion, and they certainly weren't flying away. They were staying with Jupiter. There were other moons besides the Moon, and new centers of motion. Stunning!



Credit:NASA

The observation though that killed the Earth-centered model of the universe was seeing all the phases of Venus - new Venus, quarter Venus, and most importantly the full phase of Venus. This observation is impossible to explain in a geocentric model. It can only happen if Venus orbits the Sun. And this single observation seriously hurt and put the nail on the coffin of the geocentric model. We were not at the center of the universe - with all its physiological implications. Let's explore both geocentric and heliocentric models for the phases of Venus.

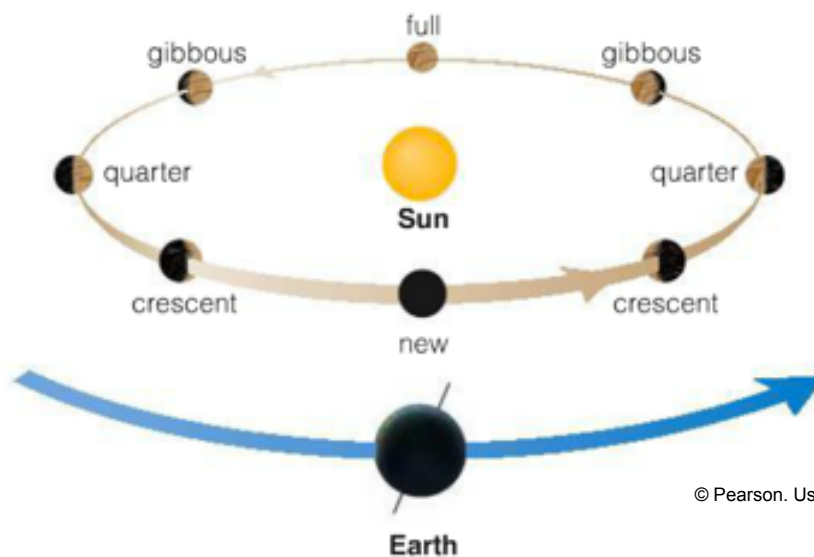
Ptolemaic View of Venus



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The image above shows an Earth-centered model, so the Earth is in the middle. And there is Venus with its large circle, and then its small circle, its epicycle and its deferent, its circle-on-circle motion. As Venus goes around its small circle the image shows the phases of Venus that you would see. Venus goes from a new phase, up to a quarter phase, and then back into the new phase. So it oscillates back and forth between a quarter phase and a new phase. You never see Venus in the full phase. That would be impossible in this geometry.

Copernican View of Venus



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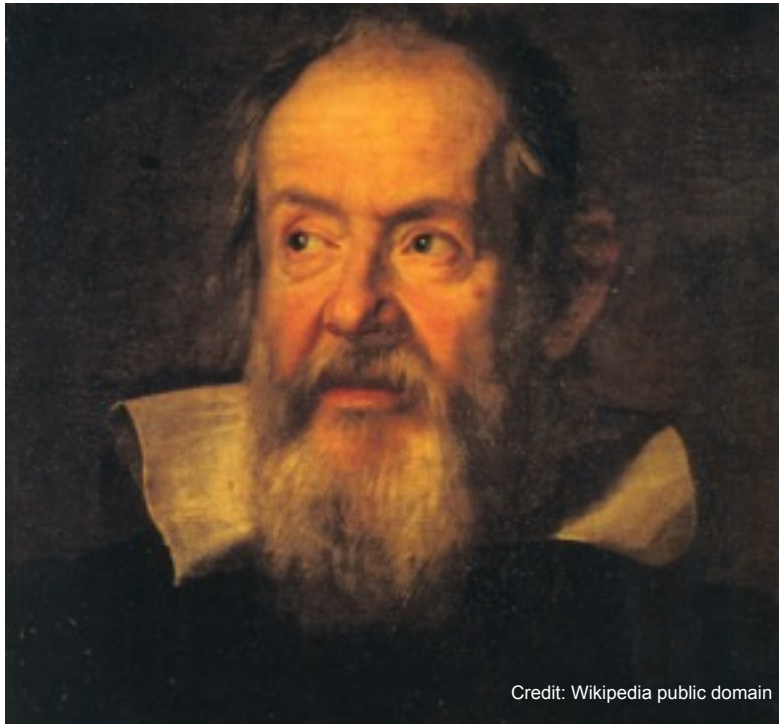
The image above shows the situation in a heliocentric model. As Venus orbits the Sun, one naturally gets all the phases of Venus - including a full Venus phase. When Galileo reported seeing all the phases in *Starry Messenger*, the conclusion was inescapable - the Sun was at the center. Case closed.



Credit: Wikipedia public domain

Now, Galileo is a PR whirlwind. He doesn't want to keep this strictly in intellectual circles (Latin). So he writes what became his scientific and the literary masterpiece, *The Dialogue Concerning Two Chief World Systems*. The two chief world systems are the geocentric and heliocentric models. He wrote it in Italian, a common language of the people, so that he could take the case to the people and let them see and debate the evidence for themselves.

In *Dialogue*, the merits of both the Ptolemaic and the Copernican systems are discussed by Filippo Salviati, who's a committed Florentine Copernican. He's the ultra cool modern guy. He's going with the Copernican theory. Then you have Gio Francesco Sagredo, who's an open minded Venetian, so he's initially neutral. He's not sure which model is right, but he's going to weigh the evidence, and make a rational judgment. Finally, you have, Aristotle Simplicio, who is a staunch unmovable follower of the prevailing Ptolemaic theory. If Aristotle (the original) said so, so it must be true. I'm not going to look through a telescope. I'm not going to look at the evidence. Aristotle said so, it must be true. These three characters were a reflection of the state of the times.



Credit: Wikipedia public domain

It's a great book. Its not that long at about 180 pages. I invite you to read it sometime in your life. The image above is the book cover.

The book created a lot of problems for Galileo, particularly since Aristotle Simplicio had several characteristics of the Pope who was a friend of Galileo. That landed him in a bit of political hot water and he was condemned in 1633 for the principles on which *The Dialogue* rested upon. He was eventually pardoned in 1992.

The real story is a little bit more complex than that kind of a popular account. Galileo did promote some ideas that were politically embarrassing to the Pope, who I said was his friend. He also aired some marginally heretical ideas. But most of all, he didn't possess a super agreeable personality. He didn't suffer fools lightly. If he thought you were being dense and weren't getting it, he would let you know. It was kind of a combination of all these things that led to his condemnation in 1633. Under house arrest after his condemnation, by several independent sources, he stomped his foot on the ground and said "Eppur Si Muove," or in English "And yet it moves". Meaning the Earth orbits about the Sun, despite what punishments you dole out.

Ultimately, through his PR campaign, we see in retrospect that Galileo nailed shut the case for a Sun-centered solar system.

Carpe Diem! Bye Bye.