

The slow growth of humility

The Fault, Dear Brutus, lies not In the stars but in ourselves

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Abstract. Galileo's stunning discovery of the four largest satellites of Jupiter forced the overthrow of the Earth-centered cosmology that had dominated astronomy for centuries. Such a fundamental transformation of the Western World's view of its importance in the cosmos could be expected to produce some humility in society. However, the deep desire for our uniqueness continues to struggle with the astronomical evidence.

Keywords. Galileo, History of Astronomy, Huygens, Cosmotheoros.

1. Introduction

This essay is a brief exploration of the social effects of the gradual growth in our knowledge about the configuration and dimensions of the universe. It is this aspect of Galileo's discovery of Jupiter's satellites that draws our attention.

The famous physicist Christaan Huygens (1629-1688) commented on the discovery and its consequences in a charming little book called *Cosmotheoros*. We will repeat some of his perceptions for their remarkable freshness.

What were society's responses to the sudden, stunning loss of our apparent importance in the cosmos that was created by Galileo's observations? That sense of importance was based on centuries of belief in an Earth-centered universe: a stationary Earth in the center of the solar system with the entire universe revolving around it. The importance of the humans who lived at the center of this system was self-evident. It was strongly reinforced by the religions that embraced it.

There is a latent paradox in this inquiry. The growing awareness of what a cosmic fleck we are in a universe over 90% of which is dark matter that we do not understand may indeed invoke a humbleness within us, yet our remarkable ability to achieve this awareness is at the very core of what makes us proud, even arrogant. We can find both attitudes manifested in human behavior.

2. A glimpse of ancient history

Aristarchos of Samos (310-230 BC) is generally credited with the first serious suggestion of a heliocentric solar system. Nevertheless, he also published a book supporting the geocentric configuration, by far the dominant model of the time. Much later *Hipparchos of Nicea* (~127 BC), the greatest astronomer of the classical period, expressed solid support for an Earth-centered solar system. His work strongly influenced Claudius Ptolemaeus, known in English as Ptolemy (90-168 AD) the final, definitive defender of

geocentrism. Ptolemy's elaborate model could explain the apparent motions of the planets better than any previous work. The Islamic contributions to this problem culminated in the work of *Ibn Al-Shatir of Damascus* (1304-1375). Al Shatir developed a theory of the moon's motion identical to that of Copernicus.

3. Copernicus (1473-1543)

The great contribution of Copernicus was to substitute a sun-centered solar system for Ptolemy's geocentric model. He could not predict planetary motions better, but he showed that a heliocentric model had a simplicity and elegance that were a tremendous advance over geocentric models that required ever more moving parts to explain the improved observations. However, the Copernican scheme posed several deep philosophical and religious problems by removing the Earth from the center of the universe and by having it move through space. The Earth became just one more planet and its inhabitants could no longer claim an especially favorable connection with the cosmos.

4. The power of geocentrism

Before we consider Galileo's far-reaching discovery, we should ask why Geocentrism was universally accepted by leading scientists and intellectuals around the world for such a long time. Counting just from Hipparchos (127 BC) to Copernicus (1543) the span of acceptance was 1670 years. Not bad for a theory that was completely, gloriously wrong!! The obvious scientific reason was the ability of this model to satisfy the existing low-precision observations. But there were deep emotional reasons as well. Geocentrism = Egocentrism. The model satisfied a strong human urge to be exceptional, to have a position in the universe that was central and therefore unique. It can be argued that this desire is the natural consequence of an experience that every human being on the planet shares viz., being born! A baby is literally the center of the universe it knows, with all other visible bodies going around it (Figure 1).



Figure 1.

Our naked eye observations of the sun, moon and stars fully support this view. It is immediately obvious that the Earth, and we upon it are very, very special.

The reluctance to give up this simple, exalted place in the universe is so strong it has stayed with us in various forms despite the advances of science.

5. Galileo

Galileo's wonderful discovery of Jupiter's satellites is well known and is reviewed in detail at this symposium. Here we shall just give a very brief summary. The wonders he found with his telescopic survey of the night sky are documented in his fascinating book *The sidereal messenger*. This is how he relates his first, unknowing glimpse of Jupiter's satellites when he turned his telescope on Jupiter itself:

"...there were two stars on the eastern side and one on the west. The most easterly star and the western one appeared larger than the other. I paid no attention to the distances between them and Jupiter, for at the outset I thought them to be fixed stars, as I have said. But returning to the same investigation on January eight - led by what, I do not know - I found a very different arrangement. The three starlets were now all to the west of Jupiter, closer together, and at equal intervals from one another."

"Led by what I do not know". With those seven words, 1670 years of astronomical thought were about to be overturned. Human perception of the universe and our place in it would be forced into a mind-bending change.

How did Galileo feel when he recognized what he had found? Christiaan Huygens gives us an idea:

"Jupiter has his four moons which we owe to Galileo, and anyone can imagine that he was in no small rapture at the discovery." (Huygens, 1695)

This great "rapture" was felt by many of Galileo's contemporaries as well. When added to his other observations the elegant Copernican model for the solar system was now indisputable. What were the effects of the Copernican revolution on Society?

6. The post-Copernicus world

Even with Galileo's great discovery the seductive power of the geocentric model died a slow, difficult death. When Isaac Newton entered Cambridge University in 1661, the Ptolemaic model was still being taught. A survey carried out 344 years later in 2005 found that 20% of Americans still believe that the sun goes around the Earth.

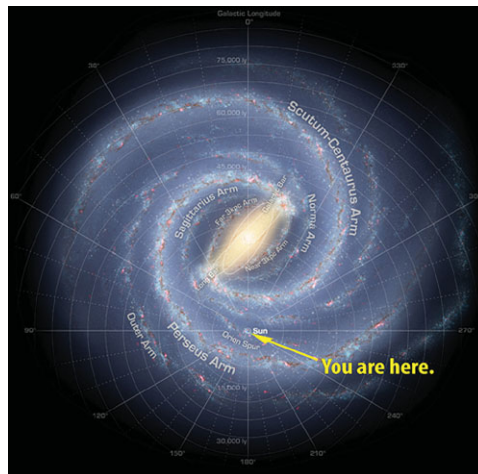


Figure 2. An artist's view of our (Milky Way) galaxy showing the position of our solar system.



Figure 3. The barred spiral galaxy NGC1672 (NASA).

The comfortable feeling that everything in the universe moves around us, that we are the center of all activity in the cosmos, that conviction of our exalted importance was too wonderful to give up.

A quick look at history shows us there have been many examples of post-Copernican leaders who still felt the world should revolve around them.

For the rest of us, the sense of our uniqueness has continued to diminish. In what other ways could we be “special”? Perhaps it’s our star.

No! There are at least 20,000 stars like the sun in our galaxy.

Maybe we occupy a special place in our galaxy - in the center?

No! We’re not even near the central bar (Figure 2).

Other galaxies also have bars, some relatively larger and better decorated than ours (Figure 3).

So even our galaxy isn’t special. It is certainly not the center of the universe - which has no center, and it is only one of thousands of billions of galaxies (Figure 4).



Figure 4. Part of the Coma cluster of galaxies. Almost every object you can see in this picture is a galaxy and the cluster contains many more. (NASA)

7. So how do we rate in the Cosmos?

There's nothing exceptional about our sun, our position in our solar system our position in our galaxy, or our galaxy itself. What else might satisfy this deep human longing to be first, best or even unique?

This quest takes us back to the Earth. This time we consider its intrinsic qualities, using criteria our ancestors could not appreciate. We can now compare the Earth as a planet with the other planets in the solar system and in that comparison our world is certainly unique.

It turns out that our position *is* important even though we are not at the center of the solar system. Our planet is in a nearly circular orbit at just the right distance from the sun to allow open bodies of water to exist on its surface for billions of years. The contrast between the arid, battered surface of the moon and the cerulean Earth with its thick atmosphere dappled with white, water-bearing clouds is beautifully illustrated in this famous Apollo 8 picture (Figure 5).



Figure 5. Earthrise at the limb of the moon as seen by the Apollo 8 astronauts.

But images like this also awakened some widespread humble feelings about our place in the universe. This cosmic jewel on which we live has been revealed as a fragile world whose well-being is essential for our continued existence. Without the good health of our planet we would disappear, regardless of all our proud accomplishments. This forces us to accept a humble position far lower than anything our ancestors could have imagined. There are probably other planets fundamentally like ours in the galaxy. Specialized telescopes that are designed to detect them are currently in orbit. These planets, if they exist, may or may not carry living organisms, possibly even intelligent life.

It is obvious that the existence of sentient life is surely the most unusual aspect of the world we inhabit. Yet the manner of life's origin, how extremely difficult it may be, remains hidden from us. The colorful ribbon of evolution leading from self-replicating molecules to art, music and poetry may unwind this far only rarely in the universe.

This possibility is also subject to experiment as scientists listen with powerful radio telescopes for intelligent signals from other worlds.

Should we really be undertaking such investigations or are we stretching our imagination too far?

The discovery of an advanced civilization on a different world would be the final challenge to our egocentrism. This was not a problem for Huygens who was quite taken with the idea. It was the main subject of Huygens' *Cosmotheoros*. He was a firm believer in the possibility that there were life forms on all the planets in our solar system and he described their probable characteristics. This was hardly a popular opinion in his day and he took pains to defend his arguments against both secular and religious skeptics. Galileo had shown the way in 1615, quoting a telling epigram from Cardinal Baronius (1538-1607):

"The intention of the Holy Ghost is to teach us how one goes to heaven, not how heaven goes"

Huygens offered more details:

The Secular Issue: Is it worthwhile to consider such a hypothetical problem? *"Conjectures are not useless because they are uncertain. In such noble and sublime studies as these, 'tis a glory to arrive at probability, and the search itself rewards the pains'.*

The Religious Issue: How could there be other beings if they were not mentioned in the Bible? *"God had no design to make an enumeration of all his works. Under the general name of stars or Earth are understood all the heavenly bodies, even the little gentlemen around Jupiter. So why must all those beings, which God has been pleased to place on these bodies, be excluded?" C. Huygens 1695.*

These are good arguments even today. We may be in the same intellectual position our ancestors were in the pre-Copernican world. Some scientists believe the emergence of intelligent life is so unlikely that we could be its only manifestation in the galaxy. A search for alien intelligence is accordingly a waste of time and money. Others are more sanguine. They are waiting for a modern Galileo to find evidence for other civilizations on other Earth-like planets orbiting other stars.

This will be the final proof that we are not the center of the universe. What would be the result of such a discovery? Will it kindle the humility that will finally make us kind to one another?

We know what we would like, but history doesn't make us optimistic.

We can give the last word to Huygens.

For Huygens this image of the Earth taken by the Cassini spacecraft from its orbit around Saturn (Figure 6) would have had a profound impact. It emphasizes the insignificance of our planet on a cosmic scale. 400 years after Galileo's epochal discovery of Jupiter's moons, 290 years after Huygens' *Cosmotheoros*, we can only echo the wish he expressed so well:

"This [new scale of the solar system] shows us how vast those Orbs must be, and how inconsiderable this Earth is, the Theatre upon which all our mighty Designs, all our Navigations, and all our Wars are transacted when compared to them. A very fit Consideration, and matter of Reflection, for those Kings and Princes who sacrifice the Lives of so many People, only to flatter their Ambition in being Masters of some pitiful corner of this small Spot." (Huygens, *Cosmotheoros*, 1695).



Figure 6. The Earth seen from Saturn by a camera on the Cassini Orbiter. To the right are a set of bright arcs from the edge of Saturn's famous rings, with the arcs of two more distant, hazy rings beyond them. Between these two hazy bands, one quarter of the frame from the right hand margin and one quarter down from the top is a small white spot. It is enlarged in the inset. This small spot is the Earth.

References

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