

Reality, Common-sense, and Science

Heitor Matallo Junior

Independent Scholar, Campinas, Brazil
Matalloheitor48@gmail.com

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Abstract

The article presents two antagonistic views of reality, one coming from modern science and the other from flat-Earthers, to discuss the relationships between common-sense, science, and reality. The concrete fact under analysis refers to the solar system and the position of the earth in this system, that is, the duality of geocentrism and heliocentrism. After discussing the reasons for denying geocentrism with arguments from theoretical physics, we return to discussing the duality against the backdrop of the history of science, showing that the issue was much more complex when the Ptolemaic paradigm passed to the Copernican one in the 16th century. The article shows that the paradigm shift presupposed the invention of a reality that took more than 100 years to stop being an invention and become a reality. From an epistemological point of view, a discovery, even if it corresponds to empirical facts, needs theoretical support to be considered true or, in the terms we are dealing with here, to be considered reality and part of common sense. Ontologically speaking, we cannot consider a certain worldview as an existing reality beyond the mental model that created it.

Keywords

Science, common-sense, Copernican revolution, mental model

1. Introduction

The idea of an objective and independent reality is controversial. Since the rise of ancient civilizations and philosophical thought, over two thousand years ago, the answers to the question "what is reality?" have changed according to the perceptions different philosophers have developed about the cosmos and the nature, perceptions that have been progressively organized into different branches of the human knowledge.

Ancient philosophers made great efforts to conceptualize the cosmos and nature, looking for the primary causes of world out there. Pre-Socratics asked questions about the root causes of existence and how to know the essence or substance of things and, ultimately, of reality. They answered the question searching for a ultimate cause as the essence of things: Water to Thales, air or atmosphere to Anaximenes, the Atoms for Democritus, and an eternal, continuous and immobile world for Parmenides. Plato's theory of forms and Aristotle's metaphysics conceived the world as constituted by a

changing apparent reality that does not represent an object of knowledge. Only the forms or essence are knowable. As Aristotle states, "I call the form, the essence of each thing, its primary substance" (Mora, 1982).

Essence and appearance are attributes of a complex thing called "reality", knowledge being the result of efforts to overcome appearance using reason. The senses deceive us and often lead us to wrong conclusions. The famous dialectician Karel Kosik (Kosik, 1976) expressed himself on the subject as follows: "'Real existence' and phenomenal forms of reality are directly reproduced in the minds of agents of historically determined praxis as a set of ideas or as categories of 'routine thinking' (considered only out of a 'barbarian habit' to be concepts). But these phenomenal forms are diverse and often contradict the law of the phenomenon, the structure of the thing, i.e., its essential inner kernel and the corresponding concept" (Kosik, 1976, 1). What Kosik is saying here expresses the Socratic and Aristotelian philosophical tradition when it comes to the production of knowledge. It is necessary to overcome appearances to know the form / substance / essence of things.

Professor Keith Wilson (Wilson, 2013) summarized the problems involved in acquiring knowledge through our senses. He pointed out in the following terms: "Taken at face value, the picture of reality suggested by modern science seems radically opposed to the world as we perceive it through our senses. Indeed, it is not uncommon to hear scientists and others claim that much of our perceptual experience is a kind of pervasive illusion rather than a faithful presentation of various aspects of reality. Following this view, familiar properties such as color and solidity – to take just two examples – do not belong to external objects, but are fictions generated by the brain that we mistakenly ascribe to the world around us" The world itself (so the story goes) is colorless, flavorless, odorless, and overwhelmingly empty save for the quantum perturbations of matter/ energy that are studied by physicists. But is this a case where science and common sense are genuinely at odds, or can philosophy help us resolve the impasse?" (Wilson, 2013, 1).

Giving credit to Kosik and Professor Wilson and many philosophers throughout history, I will take two different positions on a common phenomenon/object to discuss the issue of reality. Let's mention two different viewpoints about that the sphericity of the Earth for exemplifying the point.

The first quotation comes from the Encyclopedia Britannica (<https://www.britannica.com/video/185544/reasons-Earth>) and is summarized as follows:

Facts that prove the Earth is round:

1. We have photographic evidence;
2. During a lunar eclipse, the shadow of the earth on the moon is curved;
3. Ships on the ocean or tall Chicago buildings viewed over Lake Michigan disappear bottom first, and you can see the sunset twice if you watch it lying down and then quickly stand up. The simple fact is, if the earth were flat, there wouldn't be a horizon beyond which things could disappear. So, from across Lake Michigan, you'd be able to see all of Chicago as well as the Rocky Mountains;

4. Ferdinand Magellan and many people afterwards circumnavigated the earth. That means he left headed west, continued going west, and came back to where he started still going west.

5. The sun in general gets lower and lower in the sky as you travel away from the equator, and you can use this to directly measure the earth's curvature. Pick two places a few hundred miles directly north and south of each other, and at noon measure the shadows cast by a vertical meter stick at each location. You can use the shadow lengths to figure out the angle between the sticks, and once you add in how far apart, they are you can calculate the earth's curvature.

6. If you walk 10,000 kilometers straight along the earth's surface, turn 90 degrees to your right, walk 10,000 kilometers more, turn right again and walk another 10,000 kilometers, you'll be back to where you started, having successfully made a triangle with three 90 degree angles. This is impossible on a flat surface;

7. All the other planets and stars we've ever seen are round, and there's no reason to indicate that the earth should be any different.

The quote below represents another conception about the sphericity of the Earth, which is still accepted nowadays by a significant group of people.

“A world elite ruling in the shadows has plunged humanity into the deepest ignorance about the world in which we live. Through NASA, the educational system, and the media, we have been led to believe that the Earth is a rotating sphere that travels at enormous speeds through outer space. What they have not told us is that neither the sphericity nor the movement of the Earth has ever been demonstrated. In fact, all the scientific experiments that have been carried out to detect the movement and curvature of the Earth have determined that our world is a totally immobile flat surface. This worldview, supported by observation and experience, is the one that appears in the Holy Scriptures and the one that all civilizations have adopted throughout history” (<https://terraplanistas.org/>).

The quotes mentioned above were exposed to the same body of scientific knowledge available in libraries, bookstores, and the internet. Still, they are entirely different in terms of the use of 'reason' in information processing. Both quotes reflect a unique position on perceptions and science. Wilson called our attention to be cautious, as experience does not always inform us correctly. So, we have two different worldviews. The first is based on a body of evidence and we call it scientific. The second dismisses science as false and asserts that the Earth is flat and immobile according to our immediate senses. After all, we wake up in the morning and watch the sun moving across the sky, and the stars at night.

2. Going a little deeper in common-sense and science

The last paragraph above opposes science and common sense regarding the sphericity of the Earth. How to solve the controversy? After all, the arguments in favor of the sphericity of the Earth were presented along with all the evidence to prove the thesis, but the flat-Earthers group did not accept the evidence presented, since they still continue to propagate the thesis of the flat-Earth to all corners of the planet.

So, let's go a little deeper into the topic, since we don't want to frustrate flat-Earthers. Why? Because the reality is sometimes surprising and the statement that the Earth is a flat disk could be true, even against the general opinion of our time, or because the universe is said to be possibly flat (even though they probably don't know the meaning of "flat" in this context), and therefore one might suspect that all of its constituents might also be flat, or just because in one of the many possible universes the physical laws might be different and the hydrostatic balance would be achieved even in immobile disks floating in space, or simply because photographs taken by satellites and spacecrafts may be fake or the use of GPS may be a trick. All these possibilities are interesting and would deserve a quick look so as not to frustrate any reader's curiosity.

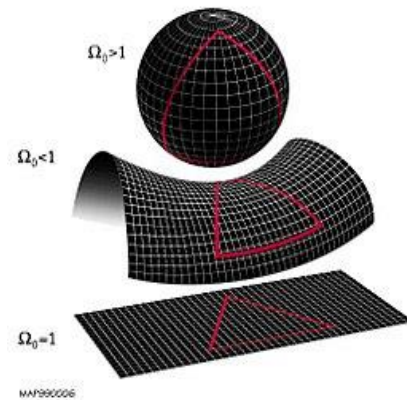
Reality is a surprising thing indeed. It is a very complex concept for philosophers and scientists, but not for regular people (most of them at least). This is because people react to the situations trusting their senses and using the common-sense to act. The common-sense is a set of fragmented information through which people organize and give meaning to what happens around them. It is a mix of different information, comprising historical facts, religious beliefs, ideologies, popularized scientific information and personal experiences. In many cases, people can provide answers to many questions about nature, the cosmos and social processes without any doubt using the common-sense worldview, 'routine thinking', as mentioned by Kosik (Kosik, 1976, 1). This is what Socrates used to call "opinion" (doxa). Opinion based on common-sense, and perceptions guide us in our daily behavior. Objects and things come to our minds not as objects of knowledge, but as part of situations to react to.

Common-sense is usually based on perceptions and perceptions sometimes fool us. The mix of illusionary common-sense and conspiracy theory is what flat-Earth advocates think is fooling us all. It is now a common-sense that Earth is spherical. Eratosthenes was the first one to measure the Earth circumference about 240 BC and it came to be a common-sense among educated people since then. There were no civilizations believing in flat-Earth and it is a myth that the flat-Earth conception was predominant in Middle Ages (Hannan, 2011; Falk, 2020) or any other time. Historians of science have been discovering amazing facts about medieval science, showing the great mistake in considering that period as being of stagnation and lack of knowledge progress. Actually, as pointed out by Hannan (2011) "the Middle Ages laid the foundation for the greatest achievement of western civilization: modern science. It is simply untrue to say that there was no science before the "Renaissance.""

It was mentioned that perhaps flat-Earthers could say that the flat universe, as some cosmologists claim using the theory of relativity, would be the substrate for a flat Earth. By appealing to the theory of relativity, it could give some apparent credibility and it would not be easy for ordinary people to understand the ins and outs of such an argument. Let's take a closer look at this.

The shape of the universe is one of the deepest questions in cosmology. It is understandable through general relativity that the concept of "shape" has to do with the amount of mass distribution in space. This is because, according to general relativity, mass causes space to bend. According to the theory, which I'm not sure if flat-earth advocates would accept General Relativity or any other physical theory, the geometry of the universe is said to have three possible "shapes" according to the density of matter and not of according to the geometric coordinates as used here in our three-dimensional space. In any case, the analogy is that the curvature of the universe could fill three possibilities: Image.

Positive, meaning that there is more than enough mass to stop the current expansion of the universe. The expansion would eventually stop and turn into a contraction. Galaxies would stop receding from each other and begin approaching each other as the



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universe collapses on itself. This is called a closed universe. Negative, meaning that there is insufficient mass to cause expansion to stop and the universe would continue expanding forever. This is an open universe. Finally, the Flat universe, meaning that the universe would continue expanding but at a negative rate and will stop at any point in an infinite time!! Cosmologists often use the figures above to show the three possibilities as an analogy, just because mass is evenly distributed in all directions in the universe. This is a property called isotropy. The triangle in the figures is an example of how straight lines would behave in each universe (closed, open but expanding infinitely, and flat but expanding at a negative rate). Until 2011, the most acceptable interpretation was that the universe was flat, meaning it was expanding, but at negative speed and at any point in the future it would stop expanding. But then, three researchers Saul Perlmutter, Brian P. Schmidt, and Adam G. Riess discovered a different result for the state of the universe: it is in accelerating expansion. The three won the Nobel Prize for the discovery and now the most accepted theory is that the Universe is open and will be accelerating its expansion forever.

There is still a final argument about the flatness of the Earth. Flat-Earthers might say that the geometry of the universe and the constant motion of its constituents (expansion) has nothing to do with the planet's local geometry. In short, it would be possible for the universe to expand in all directions, the galaxies revolving around the galactic center and all the other planets, and the sun also revolving around the Earth's flat disk, motionless in space. For this to happen, we must live in a parallel universe with a set of local physical laws valid only for Earth!!

The sphericity of stars and planets has to do with gravity. Gravity is about rotation and hydrostatic balance. For having gravity, a body must rotate, and the rotation must reach hydrostatic balance so as not to pull matter out. This is how stars and planets remain stable. Centrifugal and gravitational forces must be balanced. A flat disk is obtained when mass (or gas in the case of stars) rotates at high speed. But then another phenomenon arises. It is the tendency to fragmentation due to centrifugal force and the loss of part or all the atmosphere. All these calculations have already been done and the Earth, to be flat, should have a radial acceleration many times greater than the current one, which would cause the atmosphere, people, and part of the upper planet's layer to be thrown into space. Again, there would be no planet as we know it. However, there is something else. The Earth's rotation creates a magnetic field that protects the planet from the solar wind (magnetic storms). Without rotation, no magnetic field would exist and therefore no life on the planet. Earth would be a dead planet as it would be bombarded by deadly elementary particles and radiation.

In conclusion, the set of conditions mentioned above suffices to say that the possibility of a flat-Earth disk is not possible in our universe and possibly in no other. Even though it is still possible to speak about a “surprising reality”, there is no surprise when it comes to a flat-Earth. It is physically impossible.

But there are other possibilities for a “surprising reality”, as was shown by Professor Keith Wilson (Wilson, 2013). He shows how our minds trick us with simple things like colors or solidity of objects. Using physics to research colors and physical objects, we realize that the actual nature of colors or solidity of objects is very different from our everyday conceptions, and the understanding of these things can be very complex.

Let's take a look to another example. Imagine yourself living in the Middle Ages, when cosmology was based on Ptolemy's astronomical theory, with the Earth at the center of the Universe and all celestial objects and the Sun moving around the Earth. Your perception of the cosmos would be in line with Ptolemy's theory and Aristotelian cosmology. The relative motion of stars in the sky, the motion of the outer planets and the sun would fit your perception. Theory and common sense in perfect harmony, at least as far as what ordinary people see every day and every night. Eventually, some planets, the inner ones, tend to have a strange itinerary in the sky, but nothing that Ptolemy's theory couldn't explain by adding some geometric features. And life continues. For centuries, reality had been adapted to perception and formed the Geocentric worldview (Nigel, 2021). Difficulties in explaining disturbances in the orbits of Mercury and Venus remained a problem for experts. Geocentric worldview has been paradigmatic for most educated and also regular people. In that context, reality was well established and fitting the perceptions without any surprise.

However, among astronomers and experts, the Ptolemy's astronomical system was a nightmare. As mentioned by Hannam, “*The idea of the planets sailing serenely through the heavens was lost in a fog of fiendish geometry*” (Nigel, 2021). Several generations of astronomers tried to improve the theory and accommodate the anomalies observed in the skies but these anomalies (related to the lack of uniformity of planetary orbits and planets' speed) brought new conflicts with Aristotelians and the conception of perfection of the sky. At some point, some astronomers were clearly aware of the limitations of Ptolemy's astronomical theory. Many observations that did not fit the theory were already known by the end of fifteen century. But it was still needed a step forward in theoretical terms. A new theory consolidating the facts and the anomalies observed in the skies (Kuhn, 1985).

3. Inventing Reality

The step forward for understanding the Earth's position as no longer being at the center of the solar system was taken by Nicolaus Copernicus, from the publication of book *Revolutions of the Heavenly Spheres* (Copernicus, 1543). However, the acceptance of the new theory was not easy, mainly because it was counterintuitive, against common sense. The theory was initially interpreted as just a mathematical trick to better accommodate astronomical data and facilitate the understanding of the anomalies that appeared related to the movement of planets, to “save the phenomena” in the words of Pierre Duhem (Duhem, 1969). The theory was clearly at odds with everyday observations and common sense.

When the book finally came out of the press, Copernicus was already dead. The book's preface was written by Andreas Osiander (<http://www.webexhibits.org/calendars/year-text-Copernicus.html>), who stated that the book's content was not a fact, but a hypothesis to better explain the observations. As mentioned by Hannam, “*Osiander wrote his preface*”

because he found the idea of the Earth racing through space at high speed while simultaneously rotating on its axis ridiculous, and he knew that Europe's intellectual elite would agree" (Hannan, 2011). Astronomers' reaction to the book was not so enthusiastic. Silence and some criticism, showing that few people had read the book and that empirical evidence still should be revised thoroughly. Several generations of astronomers passed, before the new heliocentric worldview could take hold. Names like Johannes Kepler and Galileo made enormous efforts to produce evidence for the new theory. Looking back, resistance to the new theory was not due to ideology but rather because heliocentrism is counter-perception. It goes against our perception and our minds resist accepting something contrary to the senses. Great changes in representation of reality were needed for people to come to accept this view and for it to become part of common sense.

The process of mental change that involved accepting heliocentrism took almost 100 years. The ultimate change came when an entirely new mathematical and astronomical theory took hold in the minds of astronomers. This happened with the theory of universal gravitation developed by Isaac Newton and published in 1687. Although astronomers were equipped with a theoretical model to explain and consolidate heliocentrism, empirical evidence was still lacking. It took another 100 years of hard work, accurate observations and creativity to invent new instruments to collect empirical evidence to finally prove the theory and humanity's new place in the solar system.

During the period from Aristotle to Newton, two visions of the universe were at stake and struggling to prevail. Aristotle and Ptolemy with the earth and humanity at the center of the universe, a vision that lasted for over 1500 years, and then Copernicus, Kepler, Galileo, and Newton with the heliocentric system that today makes up our view of the world and is part of common-sense. The view that the sun is at the center of the solar system is counterintuitive, but nowadays it is already part of our mental model in such a way that we no longer question its veracity, unless you are one of those flat-Earth advocates.

Heliocentrism emerged giving rise to new fundamental knowledge in mathematics, geometry, astronomy, physics, and philosophy. The entire new cosmology of the sixteenth and seventeenth centuries is the expression of a new era, the Age of Enlightenment. as mentioned by Isaiah Berlin (Berlin, 2017). The great development of philosophy in Germany is also part of the Enlightenment movement. Copernicus and Newton brought a new insight about the Universe and humanity's place in it. Humanity was no longer at the center of the universe, and thus the universe has become completely autonomous, comparable to a machine, sometimes a clock, with independent existence and functioning.

Reason was the greatest "actor" of the 17th to 19th centuries. During the Enlightenment, a concerted movement to develop the scientific method, filter experiments, find data to explain natural phenomena, and use imagination to discover new aspects of reality was pioneered by ingenious minds. Can one imagine the power of Classical Mechanics and its impacts during the 18th century, when in 1846 Urbain Le Verrier predicted the existence of Neptune using pure calculus? Science and philosophy have positioned themselves as minds' achievements, giving meaning to the outside world. Two different classes of things, the external world and the thinker using the scientific method and philosophical thinking. As summarized by Kuhn, *"Initiated as a narrowly technical, highly mathematical revision of classical astronomy, the Copernican theory became one focus for the tremendous controversies in religion, in philosophy, and in social theory, which, during the two centuries following the discovery of America, set the tenor*

of the modern mind. Men who believed that their terrestrial home was only a planet circulating blindly about one of an infinity of stars evaluated their place in the cosmic scheme quite differently than had their predecessors who saw the earth as the unique and focal center of God's creation. The Copernican Revolution was therefore also part of a transition in Western man's sense of values" (Kuhn, 1985, 2). The broad sense of the quote means that the Copernican model partially represented a new paradigm since a completely new paradigm is a combination of theory, observation, and beliefs (value system) by which ordinary people adopt a common sense view of reality. In a way, it was a shift from reality itself, as geocentrism was considered the undisputed "reality" for 1500 years. Now, with a new set of beliefs and knowledge attested by intellectual authorities, new beliefs emerge as a reality.

The structure and composition of the solar system are well established today. The Sun is at the center of the system, the planets and the asteroid ring orbiting the Sun and the Moon orbiting the Earth. The position of the solar system within the Milky Way and the place of our galaxy vis-à-vis the local cluster is also well established. No controversy about it.

An interesting question arises from the time when Copernicus published his book and the decades after. In historical terms, the heliocentric reality was a creation of Mind. Copernicus used his intuition, knowledge and creativity to reformulate the observations, to build a new hypothesis, even lacking a gravitational theory to prove it. That's why Osiander wrote the preface to Copernicus' book saying that the Copernican account of the solar system was just a fabrication that had nothing to do with reality. For nearly 200 years, the reality of the cosmos was a pure mental construct.

Almost five hundred years after Copernicus, the question about the ontological status of Reality is still there. What is Reality and what does it have to do with consciousness and mind? The Anglo-Saxonian empiricists claimed that all our ideas and concepts are derived from sensory experience. Kantian philosophy gave rise to one of the most comprehensive interpretations on how the understanding, reason and experience are connected themselves, pioneering the modern theory of mind. Nowadays a whole "Quantum Generation" is discussing the connections between mind, consciousness and the status of reality (Tegmark, 2015).

Although we have had only two worldviews in the last 2,000 years (Ptolemy and Copernicus), the Newtonian gravitational theory, which substantiated the Copernican explanation of the heliocentric cosmos, was challenged, first by general relativity and then by quantum field mechanics. What happened in this period of the history of scientific thought shows that it is controversial to speak of a Reality as an objective world existing outside the mental processes that are responsible for its construction. Indeed, the history of science testifies the fragility of the concept of an external reality independent of mental processes.

As put forward by Andreas Osiander in the preface of the Copernicus's book, "*For it is the duty of an astronomer to compose the history of the celestial motions through careful and expert study. Then he must conceive and devise the causes of these motions or hypotheses about them. Since he cannot in any way attain to the true causes, he will adopt whatever suppositions enable the motions to be computed correctly from the principles of geometry for the future as well as for the past. The present author has performed both these duties excellently. For these hypotheses need not be true nor even probable. On the contrary, if they provide a calculus consistent with the observations, that alone is enough*" (<http://www.webexhibits.org/calendars/year-text-Copernicus.html>). According to

Osiander “reality” can be hypothesized and therefore it can be a narrative created to facilitate the calculations. This epistemological presupposition has ontological consequences, and the main consequence is that knowledge is not a representation of something out there, but an output of the faculty of imagination.

4. Conclusion

I began to discuss the complex issue of reality through two opposing views of Earth and its place in the solar system. The one supported by modern science and the other supported by flat earthers. My narrative shows that the idea of reality changes according to the interpretation of the facts in force at a given historical moment. Ptolemaic reality prevailed as such for 1,500 years. The Copernican discovery was initially a mental construction, supported by the rationality of geometry. Only after a long period, after accumulating evidence and strong theoretical support, did the Copernican creation become the reality we live in today. The Ptolemaic model was intuitive and easily accepted. The Copernican model was intuitive and, for that very reason, needed solid arguments to be accepted, first by the scientific community and then by common sense. It seems to me that the transition from the Ptolemaic model to the Copernican model, what Thomas Kuhn called the Copernican revolution, contains many lessons for both epistemology and ontology.

From an epistemological point of view, a discovery, even if it corresponds to empirical facts, needs theoretical support to be considered true or, in the terms we are dealing with here, to be considered reality and part of common sense. Ontologically speaking, we cannot consider a certain worldview as an existing reality beyond the mental model that created it. These are themes that derive from the approach we took, although we will not deal with them here.

Finally, it should be mentioned that common sense, when counterintuitive, can generate questions such as that of flat-Earthers. We have seen that there is no scientific argument in favor of their position. Only the immediate view (guided by the sense) that the sun apparently moves around the Earth. As mentioned by Professor Wilson, “...this is a case where science and common sense are genuinely at odds” and vision fools us miserably.

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