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HISTORICAL CONTINGENCY FOR COSMOLOGY [2]-TYCHO BRACHE'S GEOCENTRIC UNIVERSE

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ABSTRACT

Before the invention of a telescope, Tycho Brache developed his geocentric model of the Universe. Some of the historical contingencies are discussed in a context of the early Scientific Revolution. Even though considered to be the simplest and a sufficiently accurate model, Tycho's geocentric model played very little role in the transition from Ptolemy's to Copernican model.

KEYWORDS: History and Philosophy of Astronomy, History of Science, Philosophy of Science, Scientific Revolution, Ptolemy, Copernicus, Tycho Brache

INTRODUCTION

Tycho Brache was one of the best astronomical observers in the late sixteenth century. He was well supported by his patrons and, at the same time, was generous to many other astronomers at that time including Johannes Kepler. In this article, some of the historical contexts surrounding Tycho's model are reviewed, together with its role during the early era of the Scientific Revolution.

Ptolemy's and Copernican Universe

Around the second century AD in Alexandria, Ptolemy came up with his geocentric model of the Universe based on all the available observational data of the time. In this model, the first heavenly body, the Moon, is orbiting around Earth in a circle called "a deferent". Then, Mercury and Venus, respectively, are moving around their small circles called "an epicycle" and their two centers of the epicycles are moving around Earth on their big circles of a deferent. At the same time, their two centers of epicycles are directly connected to the fourth heavenly body, the Sun, which is located after the Moon, Mercury, and Venus from Earth. Thus, Mercury, Venus and the Sun are more or less observed nearby when viewed from Earth. The fifth heavenly body, Mars, is located after the Sun

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and is moving on its small circles of multiple epicycles while the centers of its epicycles are all moving around Earth on its bigger circle of a deferent. In this respect, multiple epicycles are utilized to accommodate the complicating motions of Mars. However, Mars is not connected with the Sun, thus moving freely without having any positional relation to the Sun

In 1543, Copernicus published his heliocentric model of the Universe. Compared to Ptolemy's universe, Copernican Universe has one importance characteristics. The locations of two main heavenly bodies, namely, the Sun and Earth, are exchanged, thus Earth being at the center with the Sun moving around it. Between Earth and the Sun, Mercury and Venus are moving around their circles of epicycle and their centers of epicycles are moving on their circles of a deferent around the Sun. In this Copernicus heliocentric Universe, Mercury and Venus are the first and the second heavenly body from the Sun. They do not have to be connected to the Sun as in the case of Ptolemy's geocentric Universe. The fourth heavenly body is Mars which are moving around the Sun with a combination of an epicycle and a deferent as in the case of Mercury and Venus.

Tycho's geocentric model

Copernican geocentric universe is simpler than Ptolemy's geocentric one, but it is less accurate than Ptolemy's, especially in the case of Mars. In this contrast of simplicity vs. accuracy, it can be said that aesthetic and psychological factors, rather than objective and rational one, come in for the theory choice between Copernican and Ptolemy's model. Here, Tycho's model makes the situation more interesting. Tycho seems to fully understand the issues in the theory choice. He then tries to observe some stellar parallax using the largest positional measuring equipment in the measurement of the relative positions of stars on the night sky. However, he did not have any telescopes. Telescopic observations for a heavenly body such as for the Moon was only made possible several decades later by Galileo in Italy.

With no telescope at hand, even with his largest stellar position measuring equipment together with his superior dedications, Tycho fails to obtain any measurements of stellar parallax among all the stars on the night sky. In the era of naked eye observations, it is surely too daunting even to think of trying to get any measurement of stellar parallax in the modern standard because it turned out that the largest value of stellar parallax measurements was still less than an arc second degree of angle even for the nearest star. In fact, the measurement of stellar parallax was made possible only in the 1820s by a very large size telescope. However, at that time, if Earth is really moving around the Sun, to someone like Tycho, the stellar parallax must be measured. In other words, nearby stars are surely expected to show half year periodic positional shifts compared to far away background stars.

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Therefore, based on the lack of stellar parallax, Tycho concludes that Earth is not moving around the Sun, and Earth must be at the center of the Universe. This observationally supported conclusion is a devastating blow to Copernican heliocentric model of the Universe. In this Tycho's geocentric model of the Universe, the Sun is moving around Earth on a big one circle without an epicycle. All other planets are then moving around the Sun on their individual orbital circle around the Sun. In this respect, the planets have sort of their epicycles with the Sun at their common center, and the Sun and all other planets moving together around Earth. Remember that both Ptolemy's and Copernican model have a combination of an epicycle and a deferent to accommodate the planets' motions. In a sense, Tycho's model is even simpler than Copernican one because Tycho gets rid of all the planets' epicycles using the Sun as their common center of the motions.

Tycho can also explain why Mercury and Venus never deviate from the Sun more than a certain degree of angle. In Ptolemy's model, their centers of epicycle are directly connected to the Sun so that Venus, Mercury, and the Sun are tied together while moving around Earth. In Copernican model, Mercury and Venus are simply located near to the central Sun than Earth is. Thus, two inner planets, Mercury and Venus, are always located within a certain angle from Earth's point of view. In this respect, Copernican model is simpler than Ptolemy's. On the other hand, in Tycho's model, Mercury and Venus are simply bounded to the Sun within a small angular separation from because they are moving around the Sun. So, in Tycho's model, any device connecting them as in Ptolemy's model is not necessary. Also, in Tycho's model, Mercury and Venus do not need a combination of an epicycle and a deferent as in Copernican model. That means Tycho's model is the simplest one, compared to both Ptolemy's or Copernican one (Kuhn, 1957).

Comparison of three models

As far as accuracy goes, Ptolemy's model was better than Copernican one. By increasing the number of epicycles especially for Mars, Ptolemy's model can achieve higher level of accuracy than Copernican one in which the number of epicycles are limited to only one for all the planets to emphasize simplicity. The accuracy level of Tycho's model cannot possible match that of Ptolemy's. However, Tycho's model can still achieve a reasonable level of accuracy in the case for Mars, compared to Copernican one. In Tycho's model, Mars is also moving around the Sun while the Sun is moving around Earth. But the size of its circular orbit around the Sun is so big that its circular orbit even includes Earth inside. In this big circular orbit of Mars, Earth is located not at the center of Mars' orbital circle but at the corner of it. Thus, when Mars is moving around the Sun and the Sun is moving around Earth, the orbit of Mars can make an elongated circle of an elliptically shaped curve around Earth. When repeated, this elliptically shaped curve can mimic an actual motion of Mars on the night sky as good as, or at least as bad as in the case of Copernican model. Therefore, the level of accuracy in Tycho's model is as comparable as Copernican one (Kuhn, 1962).

Crucial evidences for Tycho

What about observational evidence at that time? As discussed already, the lack of stellar parallax is considered to be one of the most important observational evidence for Ptolemy's model, because it means that Earth is not moving and, thereby, it is at the center of the Universe. On the other hand, the full moon shape of Venus, allegedly made by Galileo through a telescope, can be the most important evidence for Copernican model. Why? In Ptolemy's model, when viewed form Earth, Mercury and Venus with the Sun behind are moving more or less together since the centers of Mercury and Venus are connected to the Sun. In this configuration, the phase of Venus cannot become full moon shaped. In Copernican model, since Mercury and Venus are inner planets than Earth, they can have full moon shapes from Earth.

In Tycho's model, since all the planets are moving around the Sun and the Sun is moving around Earth, all the planets can have full moon shapes including Venus. In this respect, Tycho's model can accommodates both the lack of stellar parallax and the full moon shape of Venus, each of which is the single biggest observational crucial evidence either for Ptolemy's and for Copernican model, respectively.

The following table summarize the discussions above.

	Ptolemy	Copernicus	Tycho
Simplicity	Bad	Good	Excellent
Accuracy	Good	Bad	Not so bad
Crucial Evidence	Lack of Stellar Parallax	Full moon of Venus	Both

The Table shows that Tycho's model not only has excellent simplicity and not so bad accuracy, but also can accommodates both the lack of stellar parallax and the full moon shape of Venus. Therefore, among the three, it is the best model of all. If there is anything called "a rational and objective theory choice", choosing Tycho's model certainly satisfies the choice.

Historical contingency of Tycho's model

Nonetheless, no one really chose Tycho's model as a viable model during the era of the Scientific Revolution. There seems to be some historical contingencies related with this circumstance. Most of all, it was very unfortunate that Tycho suffered a fatal burst bladder. His sudden death during the climax of his prolific career could have been the most devastating blow to the demise of his geocentric model of the Universe.

On top of it, even Kepler who worked under the guidance by Tycho refused to accept his mentor's model and then went on to work on Copernican model instead. Kepler's choice of Copernican model over Tycho's was not explainable by Kepler's rationality and objectivity alone. Instead, it seems that he was rather following a type of the Renaissance cultural tradition, a neo Platonism for the Sun. Under this tradition, the Sun was considered to be at the status of one of the magical divine identities. The Renaissance artistic activities certainly contributed to this cultural tradition. In a new painting technique called "perspective", the contrast between light and shadow was greatly appreciated and exercised during the period of the Renaissance. This appreciation then gave a rise to a new form of Platonism, a neo Platonism, toward the Sun as the ultimate source of light, thus creating a divine status for the Sun. At this moment, Kepler could have been one of those followers of the neo Platonism for the Sun. Kepler's obsession with this kind of cultural tradition, together with his psychological and aesthetic preference toward the Sun, might well explain his over indulgence in "the secret of the sky", even during his most difficult time of his life, facing the deaths of not only his mentor but also his children and wife, not to mention of his mother's arrest by the Roman Catholic church. Even with all of these difficulties, Kepler insisted working on Copernican heliocentric model of the Universe and eventually came up with his three laws of planetary motion. First, the planets are moving on an elliptical orbit with the Sun at one of the foci. Second, the planets move faster near to the Sun and move slower father away from the Sun. Third, the periods of the planets squared is proportional to the average distance between the planet and the Sun cubed. The first law is in fact the declaration of Kepler's heliocentric model of the Universe. The second is now called the conservation of angular momentum of the planets orbit. The third was called "the law of harmony" by Kepler himself.

In any respect, Kepler simply abandoned his mentor's geocentric universe, but adopted Copernican heliocentric universe.

CONCLUSION

In retrospect, Tycho's geocentric model of the Universe play very little role in the transition from Ptolemy's to Copernican model during the Scientific Revolution, even though it could be considered the simplest model and, at the same time, still the more accurate model than Copernican one. In this consideration, a scientific theory choice cannot be entirely based on some sort of objectivity and rationality alone. Rather, it is well influenced by some sort of psychological and aesthetic values with some additional cultural background, all of which can be called historical contingencies of the time.

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