Did Copernicus provide an account of observational evidence that was in any way better than that of Ptolemy?

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Abstract

In his book on the Copernican Revolution Thomas Kuhn argues that the Ptolemaic and Copernican theories accounted for the observational evidence "equally well." because both theories were able to account for the evidence at hand with approximately equal accuracy. However, it is not clear if they were able to do so equally well. Lakatos and Zahar in particular argue that the Copernican theory superseded the Ptolemaic theory because many phenomena that the Ptolemaic theory could only account for by "degenerating ad-hoc" explanations could be derived directly from the Copernican theory. In other words, the Ptolemaic theory offers a worse explanation because it has to explain away many elements that are not only easily accounted for, but necessary, in the Copernican theory. It must furthermore do so with assumptions that serve only to correct for the problems encountered and do not provide secondary predictions (as "progressive ad-hoc" explanations would). I agree with Lakatos and Zahar that this ability to "predict" more already known "novel facts" would be a decisive advantage of the Copernican theory over the Ptolemaic. However, I will argue that even using these criteria for evaluating theories the Copernican theory does not have a clear upper hand.

Introduction

The Copernican rejection of a geocentric universe is often understood to be one of the pivotal moments of the scientific revolution. The episode is usually depicted as the gradual triumph of a superior the Copernican theory over the antiquated the Ptolemaic theory in spite of resistance due largely to religious or other conservatism. But how clear was this superiority? Thomas Kuhn has argued convincingly that the Copernican theory cannot account for observed phenomena any more accurately than can the Ptolemaic. In response, Lakatos and Zahar argue that the Copernican theory nonetheless supersedes the Ptolemaic theory because many already known observations that were explained only by ad-hoc moves in the Ptolemaic theory follow directly from the Copernican theory.[1] In other words, what flowed naturally from the Copernican theory was accounted for in the Ptolemaic theory only by arbitrary moves made after the discovery of phenomena that conflicted with Ptolemaic predictions. In the following essay, I will use this criterion for comparing theories to evaluate whether or not the Copernican theory can be shown to be a clear step forward. If the Copernican theory can be understood to give a clearly “better” account in this way, then there would be a scientific reason for accepting the Copernican theory at its inception. If not, then we may be required to accept that the Copernican theory was held to be superior to that of Ptolemy, at least initially, for non-scientific reasons.[2]

Let us begin by examining the advantages of the Copernican theory.[3] The most famous advantage of the Copernican theory is that it provided a straightforward explanation of planetary stations and retrogressions that follows directly from theory without the need of add-hoc explanations. In order to accommodate the observed fact that planets appear to periodically reverse direction for a brief period, the Ptolemaic theory had to resort to the use of epicycles, the

[1] Lakatos, Imre, and Elie Zahar. “Why did Copernicus’ research program supersede Ptolemy’s?”. *The Mehodology of Scientific Research Programmes.* Cambridge University Press (1978), 376

[2] Such as Kuhn’s notion that the Copernican system was initially accepted only by those who had an ear for the “new neatness” and greater “geometric harmony” of theory, Kuhn, Thomas S. *The Copernican revolution: Planetary astronomy in the development of western thought.* Vol. 16. Harvard University Press, 1957. 172.

[3] See Lakatos and Zahar, *Why did Copernicus’ research*, 377 for their list of these advantages.

notion that planets exhibit a second circular motion on top of their supposed orbit around the Earth. Even here, however, the Copernican theory was not as clearly superior as might be imagined. While the epicyclic movement was an ad-hoc move of Ptolemaic astronomy, it was a progressive ad-hoc in that it yielded the correct further prediction that planets would appear at their brightest while retrogressing. Progressive ad-hoc moves are made all of the time in science and often yield new and interesting predictions and discoveries. the Ptolemaic theory ran into difficulty however because, in order to explain the motion of the planets more precisely, it was forced to add more and more epicycles while never satisfactorily describing the motion of the planets.

Nonetheless, the Copernican model does seem to have a clear advantage on planetary motion. Since the Earth orbits the Sun in the model, apparent retrogressions follow whenever an inferior planet[4] overtakes the Earth or whenever the Earth overtakes a superior planet. While in actual accounts of planetary motion Copernicus had to resort to approximately as many epicycles as Ptolemy and was just about as successful in predicting their locations, Copernicus does not need them to explain the fact that planets retrogress at all. Were it not the case that planets retrogressed the Copernican theory, would have to create ad-hoc explanations as to why this would be the case or abandon theory altogether. Not only do planets retrogress, but according to the Copernican theory they must.[5] Stations and retrogressions are therefore what Lakatos and Zahar call "novel facts" and the ability to provide such facts was an advantage of Copernican astronomy over Ptolemaic. While neither theory could give a simple or accurate description of planetary motion, and while the Ptolemaic theory's ad-hoc move was an acceptable "progressive ad-hoc" move, the motion of the planets followed directly from the very core theories of the Copernican theory.

Another point in Copernicus' favour was the bounded elongation of Mercury and Venus. Mercury and Venus are said to exhibit bounded elongation because astronomical observations show them never to be far from the Sun. In the Earth-

[4] An inferior planet is a planet located closer to the Sun than the Earth. A superior planet is one that is further away.

[5] For essentially the same reasons, the Copernican theory also predicts that planetary periods should, from the Earth, appear variable.

centered Ptolemaic system this could only be explained by assuming that the center of Mercury and Venus' epicycles were in constant alignment with the Sun. On top of appearing to be a very arbitrary way to achieve bounded elongation, this explanation gives Venus, Mercury and the Sun the same average orbital period which makes it difficult for the Ptolemaic theory to make any claims about their order (as they did for other planets based on their orbital period). It was common for Ptolemaic astronomers to speculate on their relative position with rather little to go on.[6]

Bounded Elongation follows much more naturally however from the Copernican theory. Once the retrogression periods of Mercury and Venus are fed into the Copernican model, it follows that they are inferior planets and that they will therefore never appear to stray far from the Sun. This was another "novel fact" that the Copernican theory was able to quite convincingly account for.

Finally, Lakatos and Zahar note that Copernicus' theory offers some very precise predictions about the orbit of the planets, their orbital periods, their distance from the Sun, the existence of the phases of Venus, etc. The fact that it was able to make such predictions does make it a (theoretically) progressive theory in their conception. This was a strong point in favour of the Copernican theory. But it is worth noting that the Ptolemaic theory also makes predictions about things such as the size of the universe and the distance between the planets (which some astronomers proceeded to try and calculate with a decent amount of precision[7]). Lakatos and Zahar note that the Copernican calculations of the distances of the planets, for instance, follow directly from theory, whereas the Ptolemaic calculations require an extra assumption about the relationship between a planet's orbital period and its distance.[8] It may also be noted that the Copernican calculations were more precise. These are both valid points, but they only show that the Copernican theory made a better prediction than the Ptolemaic theory. the Ptolemaic theory, however, was able to make a precise prediction about the size of the universe (incorrectly as it turns out), something the Copernican theory was unable to do. Both theories, therefore, made predictions that were preferable to those of their opponents in different areas. Each

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[6] Kuhn, *The Copernican revolution*, 173.
[7] Ibid., 81-82.
[8] Lakatos and Zahar, *Why did Copernicus' research*, 378-379.

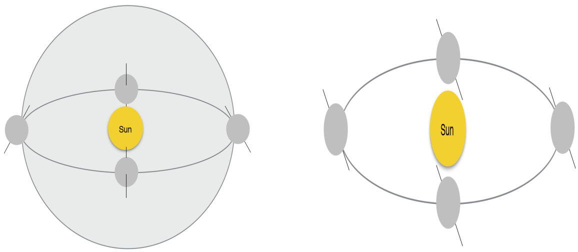
could claim that the other's calculations were unjustified given the information available. The superiority of the Copernican predictions, therefore, could only really begin to be shown once some of them became empirically confirmed by Galileo's observations in 1616.

The movements of planets make a strong case for the Copernican theory. However, Copernicus must also make use of some ad-hoc explanations that seem difficult to justify. If it can be shown that the facts which Copernicus had to explain away with ad-hoc accounts could be explained directly from the Ptolemaic theory, then it would seem to be the case that even by Lakatos and Zahar's standard the Copernican theory was not a clearly better account of empirical data until some of the predictions it made are shown to be correct.

Let us begin with the most forgivable of Copernican ad-hoc moves: The distance to the stellar sphere. Both the Ptolemaic and Copernican theories believed that the stars were fixed points on a stellar sphere. In the Ptolemaic theory, this sphere was in motion while the Earth was fixed. In the Copernican theory, the sphere was fixed and its apparent motion was due to the movement of the earth. The difficulty with this is that the Earth not only rotates around itself but is also in motion around the Sun. The first of these motions is clearly reflected in the motion of the stars, but the second should also have caused the stars to move in a circular motion throughout the year. This did not appear to be the case in Copernicus' time. So Copernicus postulated that the stellar sphere was so far away that this motion was too small to notice. This ad-hoc move is not too problematic since it was predictive. It predicted that the stars are far away enough to render this movement negligible and that if we were to develop the technology to observe them more closely (as we did), then we would observe this circular motion. However, it is still the case that this was an ad-hoc assumption and one which attempts to account for observations which in the Ptolemaic theory follow directly from the assumptions. In this case, the reducibility of the movement of the stars to the single movement of the stellar sphere made the observed movement of the stars follow directly from the Ptolemaic theory.[9]

[9] Technically, the Ptolemaic theory would also require small circular movements because the observer is not at the center of the Earth but on its surface. However, since no one believed that the stellar sphere was close enough to be affected by this small difference the Ptolemaic theory still predicts this lack of movement in a way that has to be accounted for by an ad-hoc assumption in the Copernican theory.

A worse ad-hoc move by Copernicus, one that does not entail any other predictions and so was not (theoretically) progressive, is Copernicus' stipulation of the third motion of the Earth. The third motion was introduced to resolve a difficulty for the Copernican theory due to its belief that the earth revolves around the Sun on a solid etherial sphere. This model alone would predict that the Earth would revolve around the Sun as in figure 1. However, in order to accord with celestial observation, it would have to revolve around the Sun as in figure 2. In order to enable this to happen Copernicus postulated that the Earth performs an additional rotation that allows it to conform with observation. This extra motion was a clear degenerative ad-hoc assumption because it only existed to allow theory to conform to observation and did not clearly predict anything else. the Ptolemaic theory had no such problem, and so required no such ad hoc assumption.



(a) Movement of Earth on a solid sphere (b) Actual movement of Earth

And finally, the fact that the Moon, unlike the planets, does not possess retrogressions is something that Copernicus had to explain by an ad-hoc move rarely mentioned: having the Moon revolve around the Earth instead of around the Sun. Just as the presence of retrogressions presented a problem for Ptolemy, the lack thereof posed a problem for Copernicus. There does not appear to be a clear reason why in a model in which everything revolves around the Sun there should be this one, very clear, exception. At this point, it is worth remembering, there was no theory of gravity and so no reason to believe that any object should be orbiting anything other than the Sun. The Moon's movement was however quite well accounted for by the basic assumptions of the Ptolemaic theory since it, like everything else in the Ptolemaic model, revolves around the Earth.[10]

Lakatos and Zahar want to claim that the Copernican theory was from its outset, before any of its predictions were verified, in some way a better account of the evidence than the Ptolemaic theory. However, this essay shows that it is not clear that this is the case. While the Copernican theory could derive the necessity of facts that in the Ptolemaic theory were only explained through ad-hoc measures, the Ptolemaic theory could do the same for certain Copernican ad-hoc measures. the Copernican theory explained the movement of the planets very well while Ptolemy had to resort to a progressive (epicycles) and degenerative (the account of bounded elongation) ad-hoc move in order to account for their movements. The Ptolemaic theory, however, easily explained the movement of the Sun, the Moon and the Stars in ways that Copernican could only respond to with a progressive ad hoc measure (prediction of the distance of the stellar sphere) and two degenerative ones (the third motion and the orbit of the moon around the Earth). Similarly, while the Copernican theory was able to make better predictions about the planets, the Ptolemaic theory was able to make better predictions about larger things such as the size of the universe.

This paper's conclusion entails that the Copernican theory became scientifically preferable only when it became empirically progressive in 1616.[11] The account as we have it thus far only shows the acceptance of the Copernican theory to have been "scientifically rational" only at this date meaning that its acceptance, for some portion of its history at least, was entailed by non-scientific considerations.

This may seem unsatisfactory to many who wish to show the Copernican theory to be more scientific at its inception than the Ptolemaic theory. But the above argument has the advantage of making sense of the reaction of the scientific community at the time. It explains why it was that the scientific community was so divided on the Copernican theory until Galileo made his observations decades later. And it further shows that it was quite reasonable for many astronomers to

[10] Lakatos and Zahar note that Copernicus makes more accurate predictions about the Moon that does Ptolemy (1978, p.374). However the method by which this is done, as they note, is through the use of epicycles instead of equants. Therefore, Copernicus' advantage here is achieved through the use of a tool that both he and Ptolemaic astronomers had access to meaning that it is not an advantage of his theory per se.

[11] Lakatos and Zahar, *Why did Copernicus' research*, 376.

accept Copernican theories only as a useful mathematical device to predict the movements of the planets, while retaining the Ptolemaic theory to describe the rest of the superlunary universe (namely the Sun, Moon and stars, the entities which the Ptolemaic theory appeared to explain better).

References

[1] Lakatos, Imre, and Elie Zahar. "Why did Copernicus' research program supersede Ptolemy's?". *The Mehodology of Scientific Research Programmes.* Cambridge University Press (1978)

[2] Kuhn, Thomas S. *The Copernican revolution: Planetary astronomy in the development of western thought.* Vol. 16. Harvard University Press, 1957.

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