8 Copernicus II: Is Copernican Theory True ? For Whom, Under What Circumstances - Another Look at the Scorecard

In the last Chapter we were trying to form a judgement about the 'goodness' of Copernicus' theory compared to the Aristotelian-Ptolemaic theory. We did this using facts and beliefs, current in the 16th century, because we were trying to understand the basis of their judgment without using the benefit of 200 years of hindsight. That is, we wanted to avoid Whig history. We found that we cannot simply read off the truth or falsity of Copernican or Aristotle-Ptolemaic system from the collection and weightings of facts they explain or predict, because they each have slightly different collections of facts, slightly different weightings of facts and also truth is not something that can be read directly off a theory, because you can only make out the truth of the theory by judging it upon some criteria, such as accuracy, simplicity, consistency with accepted knowledge, and confirmed novel predictions. Even then the meaning, the number and the weighting of those criteria can themselves be argued about. We tried to evaluate the two theories, and we found that Copernicanism was very probably in difficulties in the 16th century. It had nothing in accuracy or simplicity over Aristotle-Ptolemy. It was going against what was accepted knowledge, some of that being basic commitments in Natural Philosophy or physics. It made some interesting new predictions, but they did not seem to be supported by the evidence, so therefore they were viewed as false predictions.

Obviously, Copernicus was not pretending to have the benefit of the argument so far. He obviously felt that the argument so far was not very important, for there was another criterion, which Copernicus considered to be the overwhelmingly important one. It amounted to something like this: "Does your theory, taken as a whole, have any point of mathematical beauty or elegance about it ?. If it were a work of architecture, would you say it was beautiful, or ramshackle and Gerry-built ?" If it is beautiful, it is true; if it is not beautiful, it is not true. Now this sounds a very subjective judgement, but then, some of these criteria were thoroughly subjective. This criterion is what we are going to explore in this Chapter.

Before we examine this issue, we have to be reminded of one or two things. If you are an astronomer like Ptolemy or Copernicus your basic concern is to get an accurate model for the motion of the planets, one planet at a time. As an astronomer you would match up the predicted positions of the planet with the available data. You would wind up with a model on paper having perhaps an eccentric, a deferent, a few epicycles and specified speeds of rotation so that you could manipulate the model to predict the planet's positions over time. Imagine Copernicus could put the model of each of his planets on a modern overhead transparency; Mercury, Venus, Earth, Mars, Jupiter, Saturn. If you set them down one on top of the other you have a *cosmos*. Now, what if you take the assemblage of the transparencies (the superimposing of which constitutes the cosmos); what if you look at it and can see elegant mathematical features in this cosmos that you did not realise were there and that are beautiful in terms of astronomical theory. If you did that, then you would be doing something similar to what Copernicus was doing.

Now these points of mathematical elegance in the total picture Copernicus calls Cosmic Harmonies. ‘Cosmic’ because they pertain to the total cosmic theory, that is all of the models superimposed together, and ‘harmonies’ because he is thinking in terms of Greek musical and architectural theory, where simple mathematical relations are called harmonious. For example, the Greeks had discovered how to interpret the existence of nice, pleasing musical consonances, such as the octave, in terms of simple ratios of lengths of a sounding chord or string -- an octave is sounded by a chord plucked in a 2:1 ratio of lengths. Plato and his school, and before them, the Pythagorean philosophers, had been especially impressed by the way simple mathematical relations seemed to govern such beautiful physical phenomena. This idea had carried over into Greek and Roman architectural theory and was revived in the European Renaissance. A beautiful building was defined by embodying simple ratios and proportions of size and shape -- and the beautiful, in this mathematical sense, was what was sought in a good building.

Now we shall see that this element of Platonic philosophy plays a large role in the early story of Copernicanism, for what Copernicus and his early followers stressed was the presence in his cosmos of almost architectural mathematical relations which made it not only pretty, but necessarily true--in their view! The Copernican cosmos was a beautiful building made by God the architect, whereas the Ptolemaic cosmos was, in their view, a mess, not embodying harmonies, and thus not the sort of cosmic building that God would have bothered in fact to create! So Copernicus’ key contention was that if his cosmos had these mathematical harmonies in them, then his cosmos must be the true one.

Figure 1, diagrams I to VII, outline the architectural points or Cosmic Harmonies that Copernicus discerns in his cosmos: The fine mathematical relations that he thought his cosmos possessed, that the Aristotelian-Ptolemaic cosmos did not have.

Let us look at just two of these cosmic harmonies, you can study the others from the diagram, with the help detailed analysis in Kuhn's, *The Copernican Revolution*.

First, Why are Mercury and Venus never very far away from the Sun? (diagram I). This was a ‘fact’ accepted in astronomy since the Babylonians, and well known by the Greeks, and Medieval and Renaissance Europeans as well. Mercury and Venus follow the Sun around the sky or sometimes the Sun follows them, but these planets are never far away from the Sun. Each of these two planets has a rather small angle beyond which it is never further away from the sun in angular terms. Ptolemy knew this and accepted this as a fact. Ptolemy explained it by as usual having the Earth in the middle of the cosmos and making up a rule for constructing the model of Venus’ motion: The centre of the epicycle of Venus must always lie on the line joining the Earth and the Sun. This is why Venus has an orbital time around the Earth, west to east, of 365 days on average. And, this means that it is never very far from the Sun; it can be at one end of the epicycle or the other and the angle as seen from the Earth is within the angle *beta* in the diagram. Therefore, Ptolemy accepts the fact and explains it theoretically.

Copernicus also accepts as a fact that Venus is never very far from the Sun, but, he disagrees with the rule for Venus’ epicycle. Copernicus states that Venus is never very far from the Sun because the Earth is in the third orbit around the Sun and Venus is in the second orbit. So, when we look in toward the Sun we inevitably look towards Venus as well because of our larger orbit. Copernicus has the same facts as Ptolemy, but in his view this fact is explained simply and directly by the architecture of the orbits of the earth and Venus--provided the earth has an orbit! Copernicus considers this more stylish and harmonious than the Ptolemaic rule of Venus' epicycle, because Ptolemy has to add an extra rule or aspect to his model to account for the agreed fact. There is no difference in their observed facts or in the accuracy with which they can predict the facts, but there is a difference in architectural elegance. You have to almost be a student of aesthetics to see the difference in their views -- but there is a difference. Copernicus, acting in a rather 'Platonic' manner believes his model must be true because of its mathematical elegance.

The second cosmic harmony to be discussed involves the retrogression of the planets. (diagram III). We have already seen in Chapter 6 how Ptolemy explains the retrogressions and retrogression periods of the planets by using one largish epicycle for each planet for this purpose. This is recapped in diagram III. For his part, Copernicus has a rather daring claim to make. He states that if you relate the Earth's orbit to those of the other planets you will immediately see that the planets do not actually retrogress, they only seem to do so! (diagram III). The illusion of retrogression appears when the Earth, moving in its orbit, comes up from behind an outer (slower) planet, like Mars, Jupiter, or Saturn, and passes the planet like a runner lapping a slower runner. As we observe Mars, Jupiter and Saturn from the moving Earth, the planets seem to slow down, back up, slow down, stop and then resume their normal course. This also applies to the inner planets, Venus, and Mercury -- they are faster than the Earth and therefore, lap the Earth. As we observe them lapping us, we see them apparently slow down, move backwards, then slow down and resume their normal path. So, there are no retrogressions, no loops in space, there are only geometrical relationships between the planets in their orbits, which when viewed from the moving earth make the loops appear to us. Copernicus therefore also adds that he can remove five of Ptolemy's epicycles, the ones used by Ptolemy to explain retrogressions; although, as discussed later, he has to add other new epicycles for other reasons.

This is one of the best examples of what Copernicus considers an architectural or a mathematical elegance in his theory. Copernicus does not have a more accurate prediction of apparent retrogression; he does not have more accurate prediction of the data of planetary positions; he has in his view, a more elegant theory. That is because (apparent) retrogression is now explained simply as arising from the geometry of the relations of the orbits (provided the earth moves on an orbit!), whereas Ptolemy needed a special epicycle for each planet to explain its (real) looping.

Copernicus has other harmonies as well, which also follow from the relationship of the orbits of the planets in his system. These are fully discussed in Kuhn *The Copernican Revolution.*, and outlined in the rest of Figure 1.

In sum, Copernicus is telling us that this criterion of elegance is the whole emphasis of his system. His attitude is that he wins the game on this basis of the cosmic harmonies. But that is only on his scorecard. The Aristotelian answer to this is that the Copernican theory is false: his new predictions are false and the entire theory is inconsistent with the way the world is known to be -- the earth does not move, there is no evidence for that at all. To an Aristotelian the elegance of Copernicus' theory is unimportant, because in fact, in reality the Earth does not move. The so-called harmonies are artefacts on paper -- how can they make a physically impossible theory true? Indeed! So, recalling the last Chapter, we see again that what is unimportant to one side is essential to the other, and interestingly, major debates over scientific theories are often something like this.

We are therefore presented with two immediate historical and biographical problems: Why is Copernicus emphasising these ‘harmonies’? And, why would anyone agree with him? The first thing we need to say about Copernicus is he was Polish. In the 16th century Poland was the 'wild east' of European civilisation, distant from the cosmopolitan centres of Italy and Southern Germany. After all, next to Poland was Tsarist Russia which had not even begun to become the half-Europeanised country that it became in the 18th and 19th centuries. Poland was the end of European civilisation so perhaps, because Nicholas Copernicus came from a distant part of Europe he had a different attitude to what was happening in Europe than perhaps people from more cosmopolitan centres.

Nicholas Copernicus, as a young man, went to Italy to finish his education, where he stayed for 8 years until he returned to Poland. He took minor orders in the Church and became a Canon (Church Official) in a Cathedral. In Italy he was exposed to the best of both worlds. At the University of Padua, near Venice, he polished his Aristotelian education (Padua was the leading centre of Aristotelian discussion and debate). In Italy, which was about to be invaded by the great powers--the French, Spanish and Austrians--Copernicus was also exposed to the tail-end of Italian Renaissance culture.

The Renaissance means many things, but for our purpose, in trying to understand the young Copernicus, it has two main aspects. The first is Humanism. One way of looking at Humanism in the Renaissance is to say that it was a serious and concerted attempt to reach back across the Middle Ages, back to Greek and Roman authorities (writers) especially in the so-called human studies such as: Philosophy, Rhetoric, Classical Latin, Ancient Greek, Ethics, Ancient Political History. The purpose of Humanism was to have something to teach to young Italian gentlemen (this is before it spread all over Europe) that they could not get from their Scholastic professors in the Universities. Humanism was supposed to be a relevant body of learning that enabled gentlemen to function in the real world as a diplomat, administrator, a person of affairs, and so on.

A key aspect of 16th century Humanism was that Humanist scholars were beginning to run out of ancient literary, historical and poetical texts to examine, so they had started to look at some of the unstudied or understudied scientific and philosophical works of antiquity, something that the earlier Italian Humanists had not done very much. So, right about the time of Copernicus, some astronomers, who had been touched by the Humanist outlook in culture and scholarship, were saying that it would be interesting to go back to something like the original (Greek) text of Ptolemy, to try to reconstruct the original text and to discover whether what the great Ptolemy had really said had been preserved or distorted by the long intervening tradition of Moslem and Christian Medieval scholarship.

Among the Humanists of the Renaissance, Aristotle was not the favoured philosopher because his philosophy was the heavily entrenched foundation of the Scholastic Universities. The Humanists’ hero was Aristotle’s teacher, Plato, for he had been a philosopher of art, had written elegant dialogues and was seriously interested in politics. To them Plato had a wisdom and an artistry that Aristotle, who seemed to them a stodgy pedant, did not seem to have.

Plato’s philosophy differed from that of Aristotle in many aspects; but; the crucial one here is that as far as Plato was concerned Nature was constructed on a mathematical blueprint. Plato and Aristotle disagreed strongly on this point. As far as Aristotle was concerned, mathematics was not fundamental to reality: mathematics was a human abstraction made by looking at and observing everyday objects. Plato's own treatise of Natural Philosophy, the dialogue titled *The Timaeus*, had emphasised that the cosmos was divinely constructed on the basis of an elegant mathematical blueprint, full of simply mathematical harmonies. To be a Platonist in the Renaissance involved some sort of commitment, at least in general, vague terms, to the correctness of this rather non-Aristotelian faith in the mathematical structure of reality. So clearly, there was a Platonist streak in Copernicus and he was expecting to win the debate over astronomical theory on the basis of a Platonist's interpretation of the 'score'.

Let's then consider for a moment what kind of person Copernicus was, and ask, "Why and how a certain Platonic philosophical perspective shaped his astronomy?" Well he was in many ways still an Aristotelian (we see this in some of his subsidiary arguments for his system), but he was also strongly tinged with Humanism, and Platonism, from his Italian University days. Given this, there are several viable hypothetical stories of how he arrived at his theory and its justification and this is just one of them:

Like other young humanistically influenced astronomers of his time, the young Copernicus examined the versions of Ptolemy that had been supposedly cleansed of their layers of Medieval/Scholastic interpretation. He was disappointed in the results. As far as he could tell, getting close to Ptolemy's original system was no better than the Medieval version of his system which had come through the Universities. Many people had realised this after examining what was considered an improved text (or version) of Ptolemy.

But there was something about the 'real' Ptolemy that especially annoyed the young Copernicus (whereas it did not bother other astronomers). What disturbed Copernicus was that the Ptolemy of the 'improved texts' used equants within his planetary models, just as the traditional versions of Ptolemy did (cf Chapter 6). Copernicus was aghast at Ptolemy using equants, instead of uniform circular motion about the centre of deferent circles, and he considered the equants a 'cheat', a violation of the original rule of Plato (cf Chapter 6) that astronomical models use only combinations of uniform circular motions. He seems to have thought that uniform circular motion around a point not in the centre of the deferent circle violated the rule. He was determined to build an astronomy without equants.

But why? In the whole astronomical tradition nobody else had reacted so against the equant. Well, perhaps it was a combination of a kind of devotion to Platonism, combined with a kind of rough and ready, "bush" attitude to the literal meaning of Plato's famous rule for astronomy. Perhaps being from the frontiers of Europe and suddenly being thrust into the middle of a great, sophisticated humanist search for the 'real' Ptolemy prompted this oddly insistent attitude.

Now, Copernicus was a clever astronomer and he saw that the equants can be removed, but the catch is, that every equant you remove mathematically has to be replaced by two epicycles, or an epicycle on an eccentric, therefore, Copernicus ends up with more epicycles than the Ptolemaic system. At this point, Copernicus remembered something out of the ancient literature about astronomy; There had been an ancient Greek astronomer named Aristarchus who had suggested a Sun-centred system. Copernicus tried, for purposes of model building putting the Sun in the centre of his cosmos and by doing so he rid the system of retrogressions, meaning that he can get rid of 5 epicycles, which is nice, since he has had to add extra ones to get rid of the nasty equants!

So, Copernicus assumes the Sun is in the centre of the system as a hypothesis and spends many years figuring out Sun-centred models for Mercury, Venus, Earth, Mars, Jupiter and Saturn. This takes an enormous amount of time because they have to be worked out to be as accurate as the Ptolemaic models. When the models are assembled into a cosmos, it begins to dawn on him that not only are the retrogressions explained but there is a whole harmonic structure to this total system. (Remembering that Copernicus is a bit of a Platonist) he thinks that his blueprint is so elegant, that therefore, it must be true. (This path to the discovery is summarised in figure 2).

Some historians of science think that this is a plausible story of Copernicus, the 'backwoods' Humanist and Platonist, spurred by the desire to get rid of the equant, stumbling upon the beautiful blueprint, which to his somewhat Platonist viewpoint must seem, therefore, to be True. If he went through a process like this then that would explain his peculiar viewpoint: He never worried much about consistency with accepted knowledge or confirmed new predictions because he knew what he thought was important, he had experienced this process of 'discovery' and this seemed to be almost a revelation; for in Christian Platonic terms, God who is great 'architect' drew the blueprint, therefore, Copernicus' theory is God's own blueprint finally revealed to a human beings. Minor difficulties, for instance the fact that there is no shred of evidence to prove that the Earth can or does move, will iron themselves out!

Well, Copernicus may have thought that; and he may have liked his version of the 'score', but the historical fact of the matter is that few people in the 16th century agreed. Between 1543 and about 1600 you can count the number of true believers in Copernicanism in Europe on less than two hands. Copernicanism did not look like a winner in the two generations after its publication. We shall see that this was not because people were stupid or biased in the 16th century. Rather, it's because the theory did not have a good score in the view of the overwhelming majority of educated--and smart--people! This makes the historical problem look rather different. Our problem becomes one of figuring out who ever agreed with Copernicanism, and why, and how it did become established much later in the 17th century.

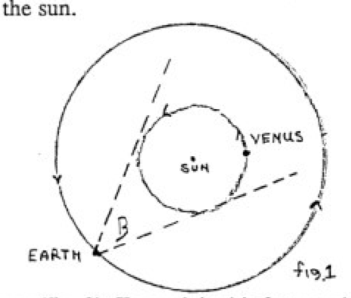
These questions will be probed in Chapters 12 to 14, and in Chapters 17 and 18 which deal with Galileo's troubles with the Catholic Church 90 years later. But, before returning to the history of the Copernican debate we are going to stop and assess in Section 3, the next three Chapters, the issue of whether the idea of scientific method (and the Whiggish view of science that it promotes) can help us understand this history, or whether it obscures and hides our access to a reasonable historical understanding. If we can free ourselves of the grip of the 'story of science' as the Whiggish 'story of method', we shall be well on the way to a demystified understanding of the origins of modern science.

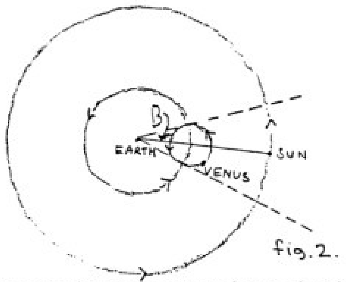
Figure 1

THE COSMIC HARMONIES: HARMONIES OF THE STRUCTURE OF THE COSMOS ON THE ASSUMPTION THAT COPERNICUS' MODELS ARE PHYSICALLY TRUE

I. Why Mercury and Venus are never far away from the Sun

Copernicus (fig. 1): We are looking in toward the sun. Venus is never more than <ß/2 from the sun.





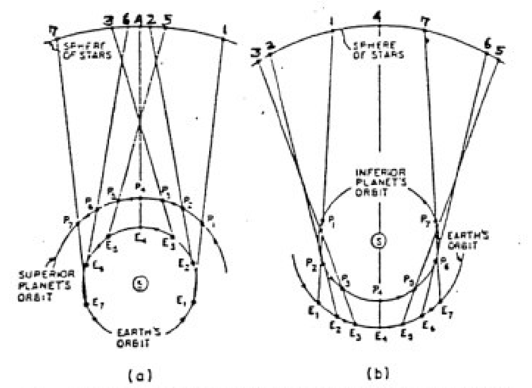
Ptolemy (fig. 2): To explain this fact you have to assume that the centres of the epicycles of Venus and Mercury always are on a line joining the earth and the sun.

II. Daily rotation of the Earth West to East explains daily rotation of each heavenly sphere from East to West in Ptolemy

[We ignore the physical problems--can the Earth really spin?]

III. Retrogression: is merely the result of an inner planet 'lapping' the earth: or of the earth 'lapping' an outer planet. It occurs when a planet is at its nearest approach to the earth.

See figure 3, from Kuhn, The Copernican Revolution



The Copernican explanation of retrograde motion for (*a*) superior planets and (*b*) inferior planets. In each diagram the earth moves steadily on its orbit from E_1 to E_7 and the planet moves from P_1 to P_7. Simultaneously the planet's apparent position against the stellar sphere shifts eastward from 1 to 7, but as the two planets pass there is a brief westward retrogression from 3 to 5.

In Ptolemy, retrogression occurs as a planet is swept on its epicyle in the direction opposite to the motion of its deferent. Epicyles must turn in the same direction as the deferent, if the retrogression is to occur at the planet's closest approach to the central earth. (fig. 4)

Venus retrogresses when carried in here, when moving on epicycle in direction opposite to motion of the deferent.

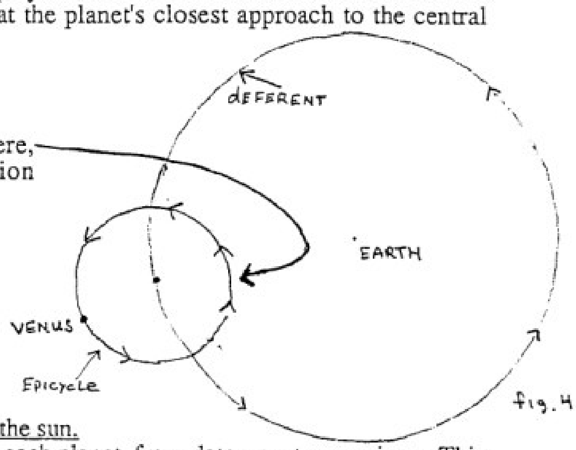


fig. 4.

<u>IV. Period= time taken by a planet to orbit the sun.</u>
<u>In Copernicus we can calculate periods for each planet, from data on retrogressions. This is important in the case of Venus and Mercury, which in Ptolemy have average periods of 1 year (why?)</u>

Calculation for Venus: Venus retrogresses every 584 days, as it 'laps' the earth. 584 days equals 1 year + 219 days. In 584 days the earth therefore goes 1.6 orbits and Venus must have gone 2.6 orbits, meaning that one orbit by Venus must take 225 days.

<u>V. Relative distances of planets from sun, taking sun-earth distance=1unit</u>

In Ptolemy such relative distances cannot be calculated, but you can make a series of assumptions that yeild a rough idea of the relative distances.
In Copernicus, simple observations and trigonometry give the relative distances

Example of Venus (figure 5)
Observe Venus at moment of maximum angular distance from the sun. In Δ VSE, <SVE is 90 deg., thus ΔVSE is a right triangle. We observe <SEV, then <VSE = 90deg -- <SEV, and by trigonometry we can get the ratio of SE to SV.

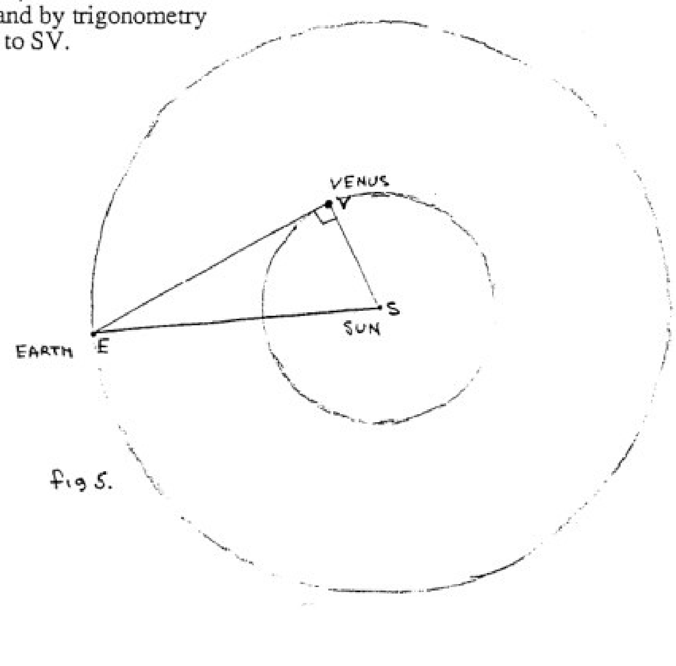


fig 5.

VI. A. In Ptolemy the inner planets--mercury, venus--must have a period on their deferents of 365 days, like the sun (Why?)

B. In Ptolemy the outer planets--mars, jupiter, saturn have large epicycles which turn with period of 365 days, and the line joining the center of epicycle to the planet always points in the same direction as the line joining the earth and the sun! (see figure 6)

In Copernicus, the outer planets do not need these 'solar' epicyles, and the inner planets have definite periods, not equal to one year. According to Copernicus A and B above are necessary for Ptolemy, because Ptolemy does not have the earth in an annual orbit; that is A and B are merely projects of the earth's motion onto the models of the motions of the other planets.

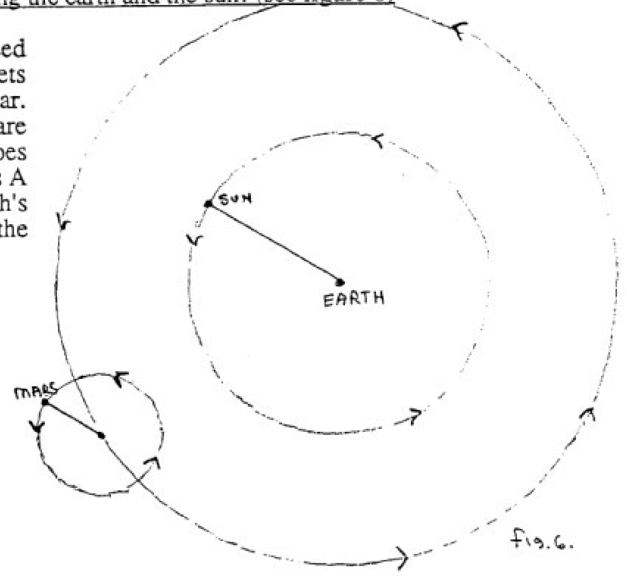


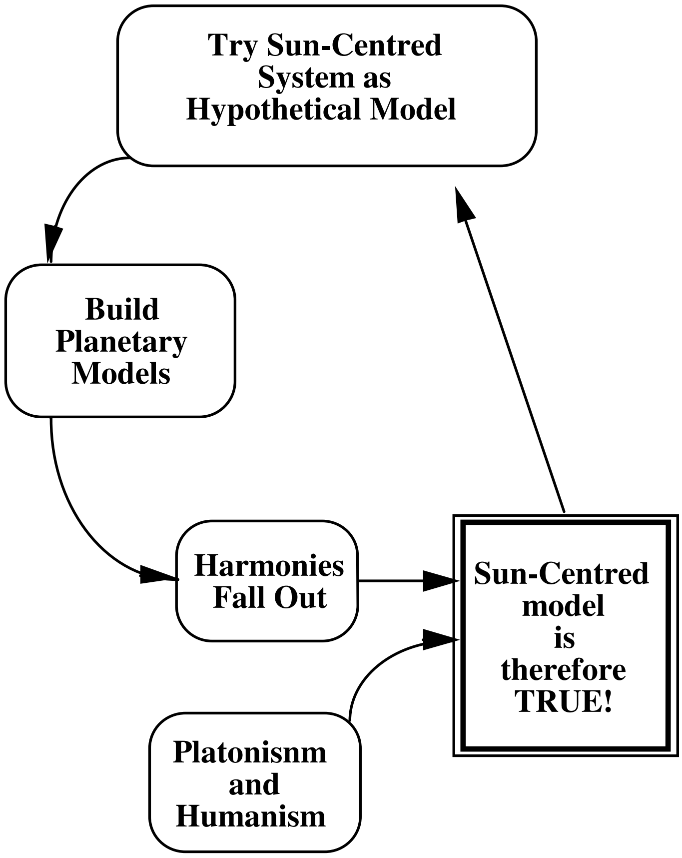
fig. 6.

VII. The Harmony of Harmonies

1. We can calculate the relative distances of the planets from the sun from observations.
2. We can calculate the periods of the planets from retrogression data.
3. **We can correlate periods with distances!**

Period increases with distance from the sun:
mercury 90 days, venus 225 days, earth 365 days, mars 2 years, jupiter 12 years, saturn 30 years

Figure 2


Try Sun-Centred
System as
Hypothetical Model
Build
Planetary
Models
Harmonies
Fall Out
Sun-Centred
model
is
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TRUE!
Platonisnm
and
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