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The Role of Observation in Plato's Method of Astronomy

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In many of his dialogues, Plato repeatedly insists that the natural world we live in is in flux, and therefore that we cannot acquire knowledge of it. He also states the difficulty of describing the natural world in the *Timaeus*, one of his late dialogus (29b–c, 48e ff.).

However, as Andrew Gregory has argued in recent years,[1] some passages of the *Timaeus* appear to suggest a substantial degree of stability (or regularity) concerning the movements of celestial bodies, in contrast with the *Republic*.

In this presentation, I shall examine Plato's method of astronomy in the *Republic* and the *Timaeus*, and argue that the role of observation in astronomy was extended between the two dialogues *because of a change in Plato's view about celestial bodies*.

I. Astronomy in the *Republic*

Many interpreters have disputed Plato's method in the science of astronomy. The main cause for this controversy lies in Plato's explanation of astronomy in the *Republic* VII (528e–530c). As is well known, in the *Republic* 530b7 Socrates explicitly states 'we will let be the things in the heavens'; because of this statement, many interpreters have argued whether observation plays any role in Plato's astronomy. Faced with this puzzling statement by Socrates, interpreters are roughly divided into two interpretive groups. One group interprets Plato as envisaging an '*a priori* astronomy' that expels observation completely. In contrast, the other group puts less emphasis on Plato's negative attitude toward observational astronomy, and attempts to assign some role to observation. In this section, I shall briefly examine the role of observation in the *Republic*'s astronomy, based on Gregory Vlastos' interpretation.[2]

When Socrates describes the method of astronomy, he is in a scene where he is explaining five mathematical subjects that the future rulers should learn (524d–531c). He introduces astronomy as the fourth subject, but the way that he explains it gives us (or at least some of us) the impression that Plato allocates too small a role to observation in astronomy. One of the main reasons for Socrates' criticism of observation seems to be that he regards astronomy as something analogous to geometry.

> "Then," said I, "we must use the blazonry of the heavens as patterns to aid in the study of those realities, …. For anyone acquainted with geometry who saw such designs would admit the beauty of the workmanship, but would think it absurd to examine them seriously in the expectation of finding in them the absolute truth with regard to equals or doubles or any other ratio." (529d-530a)[3]

[1] Gregory, Ch. 4–6, especially p.101.
[2] Vlastos (1981).
[3] All the translations of the *Republic* in this paper are taken from Shorey.

> "It is by means of problems, then," said I, "as in the study of geometry, that we will pursue astronomy too, and we will let be the things in the heavens, if we are to have a part in the true science of astronomy and so convert to right use from uselessness that natural indwelling intelligence of the soul." (530bc)

This analogy of astronomy with geometry can be summed up as the following two points:

(a) The diagrams in geometry are analogous to the visible celestial bodies in astronomy.

(b) Like geometry, astronomy should be pursued by means of 'problems'.

I think that (a) implies some important points in terms of the way the *Republic* reveals astronomy. First, the things that are studied in astronomy are not the actual observable celestial bodies, just as the things studied in geometry are not diagrams themselves. Second, the observable celestial bodies do not move in a perfectly regular manner, just as the diagrams in geometry are never perfectly drawn.

As Vlastos and others point out,[4] the 'problems' mentioned in (b) seems to be intelligible if we take this as the technical term in geometry. That is, geometrical propositions are traditionally categorized into 'theorems' and 'problems', and the latter mainly refers to construction proofs. Therefore, 'by means of problems we will pursue astronomy' seems to mean the procedure of setting problems that we want to solve (or conclusions that we want to draw) first, and finding ways to deduce them from hypotheses already acquired next.[5] It is difficult to judge whether Socrates thinks that the problems in astronomy are completely irrelevant to the observable heavens, or that they are applicable to the observable heavens. Indeed, in his discussion, the primary objects that the future rulers should study in astronomy are not the observable celestial bodies, as we have just acknowledged above. However, it is also hard to think that the problems are proposed completely independently from observation records. Therefore, if we are to see the role of observation in astronomy in the *Republic* as significant, that would be the contribution for setting problems to be solved. Namely, the role of observing the movements of celestial bodies, and setting the problem of how, and from what hypotheses those observed movements can be deduced.

If this interpretation is correct, the claim of some interpreters that Plato banishes observation completely from astronomy in the *Republic* does not seem to hold. However, on the other hand, if the role of observation is limited to setting problems, it does not play so great a role as we would expect. In reality, we know that observation in natural sciences plays a more significant role than simply setting problems. One of these roles is to verify scientific theories by checking predictions.

However, in the *Republic*, Socrates does not seem to promote the method in which students of astronomy predict observable phenomena, and verify them through observation.[6] The first reason for

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[4] Vlastos (1981), p. 5, with n. 29, p. 12. The argument in this section on the role of observation in astronomy in the *Republic* is based on his argument.

[5] Mueller (1981), p. 120, n. 13, says 'I am inclined to think that the word "problem" here does not have the technical sense of "construction" but the more general sense of "something set out for proof or refutation"'. Burnyeat, p. 15, n. 18, agrees with Mueller, and says that geometrical propositions include theorems as well as problems, and that there is no reason to exclude theorems here. However, whether theorem or problem, the procedure that Plato calls a 'problem' here seems to mean some sort of geometrical (or mathematical) method, which is, first, to set a conclusion that you want to draw, and then, to find a way to deduce it from hypotheses.

[6] However, contrary to my view, Bosanquet, p. 293, mentions the historical example of the nineteenth-century astronomers, Adams and Le Verrier, successfully predicting the existence of an unknown planet (Neptune) by doing calculations based on Newtonian physics, and claims that such a method 'seems just to fulfil Plato's anticipation' in the *Republic* (Adam, p. 165, criticizes Bosanquet on this view). This historical event is sometimes mentioned when Ptolemaic astronomy and Newtonian

this is that he repeatedly emphasizes the irregularity of the movements of celestial bodies (e.g. 529d, 530b). It is also important to note that the relation between astronomy and the observable celestial bodies is described analogously to that between geometry and its diagrams. I think that we can infer from this analogy that Plato (at the time of writing the *Republic*) thought that astronomical theories could never be verified through observation, in the same way that theorems in geometry could never be verified through observing diagrams.

Another reason for arguing that Socrates does not promote astronomical observation as a method of verification is that astronomy is described almost exclusively as a deductive research. Having explained astronomy and harmonics, Socrates attempts to explain the science of dialectic, and in so doing compares dialectic with the mathematical subjects, including astronomy, which he has explained so far.

> "… the remnant which we said did in some sort lay hold on reality—geometry and the studies that accompany it—are, as we see, dreaming about being, but the clear waking vision of it is impossible for them as long as they leave the assumption which they employ undisturbed and cannot give any account of them. …" … "Then," said I, "is not dialectics the only process of inquiry that advances in this manner, doing away with hypotheses, up to the first principle itself in order to find confirmation there?" (533b-d)

In this passage the mathematical subjects, including astronomy, are described as the sciences that consist of only deductive process, but not of the justification of hypotheses. Of course, the science of dialectic cannot be envisaged as justifying its hypotheses through sense perceptions either (cf. 532a6). In any case, this comparison between dialectic and the mathematical subjects clearly shows that the process of verifying theories by observation is not in the least considered as a procedure in mathematical sciences.

Therefore, as Vlastos argues, the astronomy of the *Republic* should be interpreted as admitting the contribution of observation only in setting problems, but not in verifying theories.

II. Movements of Celestial Bodies in the *Timaeus*

In this section I shall examine how Plato describes the movements of celestial bodies in the *Timaeus*. As Gregory argues,[7] it is fairly clearly suggested in the *Timaeus* that celestial bodies move in a regular manner. Several passages suggest that celestial bodies and the whole universe containing them move in a regular, stable manner, and to our argument, the most important of these passages is Timaeus' statement that celestial bodies were made to define numbers of time (units of time).

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physics are compared. It is sometimes said that all Ptolemaic astronomy could do was to explain the movements of the celestial bodies *already known by observation* in terms of such techniques as epicycle, equant, etc., but that Adams and Le Verrier made a prediction based on Newtonian physics and it was verified by observation. Of course, this is too simplified an explanation (and an unfair explanation to Ptolemy), but seems to fit the two roles of observation at issue. Namely, the former role (a contribution for explaining already-known phenomena) is admitted even in the astronomy of the *Republic*, but the latter (a contribution for predicting and verifying phenomena) is not taken into consideration at all.

[7] Gregory, Ch. 4–6, esp. p. 101. Furthermore, he goes on to argue that in the *Timaeus* not only the celestial bodies, but also the other ordinary natural objects have more stability than we generally interpret. I cannot agree with this view concerning ordinary natural objects.

> In virtue, then, of this plan and intent of the god for the birth of Time, in order that Time might be brought into being, Sun and Moon and five other stars—'wanderers', as they are called—were made to define and preserve the numbers of Time. (38c)[8]

It is explicitly stated here that even the planets, whose movements had been well known to appear irregular since antiquity, as well as the sun and the moon, were 'made to define and preserve the numbers of Time'. Timaeus emphasizes this point again at 39cd, stating that 'the wanderings of these others are time at all, bewildering as they are in number and of surprisingly intricate pattern', and suggests that a few astronomers would be able to 'measure [the periods of planets] one against another by numerical reckoning'. Therefore, from these remarks, it is suggested that not only the periods of the sun and the moon, but also those of the planets, are constant, and that they are commensurable.

Furthermore, Timaeus suggests that the celestial bodies have a stability that other physical objects cannot have:

> Be that as it may, when all the gods had come to birth—both all that revolve before our eyes and all that reveal themselves in so far as they will—the author of this universe addressed them in these words:
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> 'Gods of gods whereof I am the maker and of works the father, those which are my own handiwork are indissoluble, save with my consent. …. although you, having come into being, are not immortal nor indissoluble altogether, nevertheless you shall not be dissolved nor taste of death, finding my will a bond yet stronger and more sovereign than those wherewith you were bound together when you came to be. …' (38c)

Here, Timaeus seems to say that, unlike other natural objects, celestial bodies are indissoluble and therefore, factually keep moving for good.

On the other hand, however, there is a concern that the planets are regarded even in the *Timaeus* as moving in an irregular manner, as the name suggests. The most often mentioned description of the planets that might damage the idea that Plato suggests regularity of planetary movements is 'the contrary power' (ἐναντία δύναμις) that Timaeus attributes to Venus and Mercury.

> Having made a body for each of them, the god set them in the circuits in which the revolution of the Different was moving—in seven circuits seven bodies: the Moon in the circle nearest the Earth; the Sun in the second above the Earth; the Morning Star (Venus) and the one called sacred to Hermes (Mercury) in circles revolving so as, in point of speed, to run their race with the Sun, but possessing the power contrary to his; whereby the Sun and the star of Hermes and the Morning Star alike overtake and are overtaken by one another. (38cd)

In the *Timaeus*, the movements of celestial bodies are explained through a combination of two major movements. One is a circular movement called 'the Same', and the other is a circular movement called 'the Different'. The plane circles of these two orbits intersect with each other at an angle, with their centres overlapping. The circle of 'the Same' represents the celestial equator, and the circle of 'the Different' represents the ecliptic, which intersects with the celestial equator at an angle. Therefore, it is suggested that fixed stars make a diurnal rotation parallel with the Same, but the sun, the moon, and the five planets each move on their own orbits of seven concentric circles, into which the circle of the Different is divided, while they also make a diurnal rotation, carried by the Same (so the sun, the moon, and the planets rotate in a spiral manner because of the combination of the Same and the Different). It

[8] All the translations of the *Timaeus* in this paper are taken from Cornford.

is said that the Same and the Different rotate in the opposite direction from each other (36cd), and this is supposed to mean that fixed stars rotate from east to west, whereas the sun, the moon, and the planets make a slow, west-to-east rotation, relative to the fixed stars.

Out of these seven rotations from west to east on the Different orbit, those of the sun and the moon are uniform circular movements at constant speeds, but the planets, by contrast, show seemingly irregular movements, which is, ceasing the regular rotation, moving backwards, ceasing retrogression, and resuming the regular rotation. In the late fourth century BC, astronomers were particularly struggling with this problem of the planets seeming to move in an irregular way. According to Simplicius, Plato posed the following problem to mathematicians: 'by making what hypotheses about uniform, circular, and ordered motions will it be possible to preserve the phenomena involving the planets?'[9] Some interpreters have regarded the 'contrary power' in the passage cited above as Plato's own answer to the problem. Many interpreters have attempted to understand the meaning of this phrase, but Cornford's interpretation seems the most reasonable to me.

Cornford says 'Theon, Proclus, and Chalcidius all mention the view that, whereas the Sun keeps steadily on at the same pace, the other two [Mercury and Venus] move sometimes faster, sometimes slower. Since Plato nowhere says that each planet moves with a uniform velocity, this view is consistent with the text. I see no reason why it should not be accepted'.[10]

Of course, this view has its own problems. One of these is that Timaeus (seemingly) attributes the contrary power only to Mercury and Venus, which are interior planets, although the phenomenon of retrogression is a problem that is general to all the planets. However, as Cornford points out, the contrary power is not explicitly denied to the other three planets (Mars, Jupiter, Saturn), but it is only suggested that their movements need more detailed explanation. Therefore, following Cornford, I would like to understand the contrary power as a power that is opposed to the constant movement of the sun, which causes the velocity change of the planets on the circuits of the Different. As is often stated, it is true that a 'solution' of this sort is not an *explanation* of the irregular planetary movements, but only an *ad-hoc* confirmation of them.[11] However, this view is an approach that tries to maintain the regularity of the planetary movements as much as possible in a way that is at least not inconsistent with Timaeus' statement (he does not claim that the planets have a constant velocity).

Therefore, the description of the celestial bodies in the *Timaeus* allows them physical stability and regular movements, unlike in the *Republic*.

III. Astronomy in the *Timaeus*

In this section, I shall argue that, because of this change in Plato's view of the celestial bodies, he extends the role of observation in astronomy from only contributing to setting the problems to that of verifying astronomical theories.

First, as we have just confirmed in the previous section, set aside from other natural objects, the celestial bodies are given a substantial degree of stability and regularity (38c, 40b–d, 41ab, 47a–c). According to Vlastos, observation cannot play the role of verifying astronomical theories in the

[9] Heiberg, p. 493, l. 2–4. The translation is taken from Mueller (2005).
[10] Cornford, pp. 106–7.
[11] Taylor, p. 202, comments regarding this kind of interpretation that '[o]f course, this statement about the ἐναντία δύναμις is a mere record of the appearance; it does not in any way account for them'. Vlastos (1975), pp. 58–9, also criticizes this interpretation in a similar way.

Republic because the movements of the celestial bodies are regarded as not perfectly regular.[12] For, the observation of their irregular (or imprecise) movements is not deemed adequate to verify theories. As the celestial bodies are depicted in the *Timaeu*s as moving in regular ways, it is natural to think that we can verify astronomical theories by observing them.

Furthermore, I think it is possible to take the following remark in the *Timaeus* as suggesting that observations can be used as criteria for judging theories:

> To describe the evolutions in the dance of these same gods, their juxtapositions, the counter-revolutions of their circles relatively to one another, and their advances; to tell which of the gods come into line with one another at their conjunctions, and which in opposition, and in what order they pass in front of or behind one another, and at what periods of time they are severally hidden from our sight and again reappearing send to men who cannot calculate panic fears and signs of things to come – to describe all this without visible models of these same would be labour spent in vain. (40c–d)

Indeed, all we can detect directly from this remark is that Plato thinks that some astronomers can predict the complicated movements of the celestial bodies by calculations. However, the prediction in general, and whether it will turn out to be true, is what is supposed to be verified by observation. If verification by observation was not being implied, it would not be a prediction in the first place. Therefore, the passage cited above seems to suggest that the theory leading to the prediction will be judged according to whether the prediction turns out to be true or false.

In addition, Timaeus places an exceptionally strong emphasis on the role of visual perception in the sciences.

> Sight, then, in my judgment is the cause of the highest benefits to us in that no word of our present discourse about the universe could ever have been spoken, had we never seen stars, Sun, and sky. But as it is, the sight of day and night, of months and the revolving years, of equinox and solstice, has caused the invention of number and bestowed on us the notion of time and the study of the nature of the world; whence we have derived all philosophy, than which no greater boon has ever come or shall come to mortal man as a gift from heaven… For our part, rather let us speak of eyesight as the cause of this benefit, for these ends: the god invented and gave us vision in order that we might observe the circuits of intelligence in the heaven and profit by them for the revolutions of our own thought, which are akin to them, though ours be troubled and they are unperturbed; and that, by learning to know them and acquiring the power to compare them rightly according to nature, we might reproduce the perfectly unerring revolutions of the god and reduce to settled order the wandering motions in ourselves. (40a–c)

This is not a direct support to my thesis that the role of observation is extended to the verification of theories in the *Timaeus*, but nevertheless, this passage clearly suggests that observation can contribute to the formation of scientific theories.[13]

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[12] Vlastos (1981), pp. 15–6.

[13] This passage might seem to some people not even to support the view that observation can contribute to the formation of scientific theories. However, I interpret that it is said here that we can incorporate the circular movements of the heavens into our souls by doing theoretical research based on the observation of celestial bodies. Taylor, p. 295, also says '[k]nowledge of the periods of the circles in the heavens and computation of their ratios to one another... is to lead us to take up the task of bringing the disordered and "surd" revolutions of the circles in our own souls into a corresponding

Moreover, as is the case in the *Republic*, in the *Timaues* too, it seems that observation can contribute to the setting of problems. According to Simplicius' testimony, which is often mentioned by interpreters, Plato posed the following problem to mathematicians: 'by making what hypotheses about uniform, circular, and ordered motions will it be possible to preserve the phenomena involving the planets?' Whether this testimony is authentic,[14] it is true that the astronomical model in the *Timaeus* makes it more or less plausible. The attempt to answer the problem by the model in the *Timaeus* is obviously better than that in the *Republic*[15].

However, on the other hand, it is explicitly and naturally stated in the *Timaeus* that astronomical theories are constructed from metaphysical, teleological considerations (as well as from observation). Of course, it is obvious that the *Timaeus* is full of metaphysical considerations, but we might pick this up as an example: in the astronomical model of the *Timaeus*, the assumption that all celestial bodies, including the planets, make circular movements, seems to play the central role. This assumption is probably derived from the conjunction of many other higher assumptions, such as that the circular motion is superior to other forms of motions (cf. 34a, 40ab), that the universe was made by the Demiurge as the best possible creation (cf. 29a), that the circular movement is the most suitable for Time and the universe to imitate eternity (cf. 37d–38a, 39e), that the universe was brought into being together with Time (cf. 37c–38c), and other assumptions. Indeed, it is not difficult to imagine that simple observations of the celestial bodies were influential on this assumption that all the celestial bodies make circular movements. However, even after it was observed that the planetary movements appear to be irregular at phenomenal level, Plato and astronomers stuck to the plan of explaining all the celestial movements by circles. I believe that this is because of those metaphysical assumptions.

Besides this, the astronomical model of the *Timaeus* seems to assume the theses that the cycles of the celestial bodies are constant, and that they are commensurable to each other (39cd). However, those two assumptions later turned out to be false, so they cannot correspond to observations. Nevertheless, Plato determined to construct an astronomical model that was based on these assumptions. It is obvious, then, that when his model was constructed, many metaphysical assumptions were taken into account, independently of observation.

Therefore, we can argue that the investigation of astronomy is envisaged in the *Timaeus* as consisting of a combination of observational activity and metaphysical reasoning. Where the role of observation is comparatively limited in the *Republic*, it is much greater in the *Timaeus*, as is obvious from the passage 47a–c, cited above. I think that this difference comes from the difference of views in the two dialogues regarding the movements of the celestial bodies. Since Socrates says in the *Republic*

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order'. Indeed, this passage seems to suggest the similarity with the *Republic* as regards *the aim* of astronomy. However, I think that the difference between the two dialogues is suggested in how observation is used (or not used) *as a means* to attain the aim (see my brief examination of Burnyeat's interpretation in section IV).

[14] Zhmud argues that the trend of depicting Plato as an architect of sciences, including this legend, traces back to the early Academics, and may have only resulted from their interpretation of Plato's dialogues. This would mean that the legend does not reflect the reality, and that Plato did not play the role of an architect of the sciences. Burnyeat, p. 63, however, insists that 'the challenge is there *de facto* in the texts regardless of whether we believe the popular story retailed by Simplicius'.

[15] For example, as we saw above, Timaeus presents the model that combines the circular movements of the Same and the Different in order to explain the movements of the sun, the moon, and the planets (36b–d, 38e–39b). This is an attempt to explain their complicated movements that appear irregular in a simple, regular manner. At the end of the *Republic*, by contrast, a model is presented, in which all the orbits of the sun, the moon, and the planets are on the same plane. This is obviously an advancement in the attempt to solve the problem.

that the movements of celestial bodies are not strictly regular (529cd), astronomers cannot judge by observing them whether a certain model is true or false. In contrast, the *Timaeus* emphasizes the regularity of the celestial movement, and in my view, as a result of this, extends the role of observation in astronomy. However, even if the movements of the celestial bodies are regular, this does not of course mean that Plato makes little of metaphysical reasoning in astronomy.[16]

IV. Conclusion

So far, I have argued that the two dialogues have different astronomical methods, but there are many interpretations that attempt to understand their astronomy as being consistent. In this final section, I would like to conclude my argument by briefly examining Myles Burnyeat's interpretation, which might appear to conflict with the interpretation that I have argued.

In his paper, 'Plato on Why Mathematics is Good for the Soul', Burnyeat attempts to elucidate Socrates' puzzling conception of the 'astronomy of the invisible' in the *Republic* through his analysis of the astronomy in the *Timaeus*. That is, he seems to think that the invisible that the future rulers should study in the astronomy of the *Republic* is basically the same as the movements of thought in the intelligence of the World Soul (such as the circular movements of the Same and the Different), depicted in the *Timaeus*. Indeed, this approach, which understands the astronomy in the two dialogues as being consistent, is quite plausible. Note the following points:

(i) The visible movements of the celestial bodies themselves are not the movements of thought in the intelligence of the World Soul.[17]

(ii) The former is caused by the latter.[18]

(iii) The ultimate aim of studying astronomy for us is to incorporate the latter into our souls.[19]

These are all stated clearly in the *Timaeus*, and it seems plausible to apply these points to the astronomy in the *Republic*, too.

Actually, these points do not necessarily conflict with the interpretation that I have presented. Even having admitted these points, I can still claim that there is a difference *in the methods*, even if *not in the aim* of the astronomy between the two dialogues. Whereas the *Republic* does not recommend serious engagement in observing the visible celestial bodies in order to apprehend their invisible value, the *Timaeus* does, even though the observation of the visible celestial bodies in itself is not presented as the ultimate aim of the astronomy. The reason for this is, I repeat, that whereas the *Republic* emphasizes the irregularity of movements of the celestial bodies, the *Timaeus* admits their regularity to a great degree.

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[16] Observation and some sort of metaphysical reasoning are both necessary for sound scientific research in general, including astronomy. It is often emphasized in the modern philosophy of science that scientific research does not consist only of empirical activities. One of the reasons for this is the problem of underdetermination. As Duhem, pp. 273–332, has pointed out, it is not possible to judge whether a theory is true or false only from observation.

[17] Cf. 36e-37a.

[18] Cf. 36b-d.

[19] Cf. 47a-c.

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