Journal of Astronomical History and Heritage, 2(1):21-31, 1999

Plato's theological astronomy
II. *The Laws* : an old man looking back

A Sinachopoulos

Laboratoire d'Informatique Théorique, Université Libre de Bruxelles
C.P. 212, Boul. du Triomphe, B-1050 Bruxelles, Belgium
asinach@ulb.ac.be

D Sinachopoulos

National Observatory of Athens, Penteli Astronomical Station
Palea Penteli, Athens 15236
ds@astro.noa.gr

Abstract
In *The Laws*, Plato considered astronomy as socially necessary but espoused a metaphysical model for the heavens, in which celestial motions were due to souls of gods. He furthermore reasoned against physical philosophers whose ideas he found dangerous for the youth. His views on astronomy and on the necessity "to ignore the visible heavens" have been vividly discussed over the last 150 years. For more than 20 centuries astronomy was characterized by the Platonic spirit, according to which there is no need for observations but only for metaphysical theories. However Plato was not actually concerned with astronomy and, by extension, natural sciences in general; his central interest focused on how to govern his perfect state.

Key Words: *Plato's* The Laws, *observational astronomy, evolution of astronomy, souls and motion, order*

1 INTRODUCTION

In a previous article, Sinachopoulos and Sinachopoulos (1991), we have dealt with astronomy in Plato's *The Republic* (Plato1), in an attempt to explain the philosophical and political tendencies of his times. In the present work, we turn our attention to Plato's *The Laws* (Plato3) insofar as Plato's position with respect to astronomy and, by extension, the natural sciences is concerned. In *The Republic*, a work probably completed around 390 BC (Taylor, 1978), Plato, 428-347 BC, at his intellectual peak, demanded that:

> We shall therefore ... ignore the visible heavens, if we want to make a genuine study of the subject [astronomy] and use it to convert the mind's natural intelligence to a useful purpose. (Rep 530b, see Section 10, Notes 1.)

The discussions on the meaning and the significance of this Platonic saying, as well as on the role of Plato in the evolution of astronomy, have been lively during the last centuries, (see e.g. in Bulmer-Thomas, 1984; Mourelatos, 1980), or even the reference to the criticism of Hume in (Meldrum, 1950). The interpretations of the Platonic work regarding astronomy and the evolution of natural sciences, as well as the related criticism, vary significantly, for example in (Donnay, 1960; Knorr, 1990; Lloyd, 1968; Mittelstrass, 1962; Mourelatos, 1981; Neugebauer, 1957; Solmsen,

1977); some interpretations consider Plato very important for the evolution of astronomy since, according to these, he advocated a theoretical examination of the universe in much the same spirit as that of geometry. Other interpretations, including those of the authors of this work, express the opinion that Plato's teaching significantly hindered the development of natural sciences instead.

In his final work, *The Laws*, written in his old age, around 350 BC (Taylor, 1978), Plato retains his faith in a metaphysical interpretation of the world: he considers the physical world as contradictory and incomplete, the stage for constant creation, change and decay, hence unfit to be the object of scientific study. While *The Republic* treats astronomy only as far as its subject matter is concerned, which for Plato is completely unrelated to whatever is visible in the heavens (Rep 530c), his *The Laws* lay the foundations of, and fully expound, a theological view of astronomy (see also the Table of Section 11), according to which the stars and all the other visible heavenly objects are simply the divine souls of virtuous beings. In *The Laws,* the main points regarding astronomy concern the role of astronomy in communal life, the dangerous ideas of the physical philosophers, the regularity in the motion of the heavenly bodies, and, finally, the divinity of the celestial objects.

"It has always been correct to praise Plato, but not to understand him" commented Russell (1972). One of the main objectives of this work is to help understand the Platonic work, the Platonic way of thinking and some of the obstacles scientists have had to face during the centuries.

2 *THE LAWS*: GENERAL PRESENTATION

In *The Laws*, the main speaker is no longer Socrates as in *The Republic* and other Platonic dialogues but an anonymous Athenian debating, with the Cretan Cleinias as well as the Spartan Megillus what kind of legislation could lead the citizens of a town to ultimate virtue (630c; see Section 10, Notes, 1.). We follow their discussion as they walk from Knossos to the Dictean cave and temple of Zeus, following the same processional path trodden by King Minos, the lawgiver of Crete on his way to receive in that holy place the laws of his land from the hands of his very father, Zeus. For them, education is one of the basic matters of any legislation. Thus, the Athenian considers that, following basic training, there are three subjects indispensable for the education of the young (817e): arithmetic, geometry and astronomy. He points out, however, the dangers inherent in the teaching of astronomy; it can lead to atheism:

> But the principles of our modern pundits do need to be denounced as a pernicious influence. Just look at the effects of their arguments! When you and I present our proofs for the existence of gods and adduce what you adduced – sun, moon, stars and earth – and argue they are gods and divine beings, the proselytes of these clever fellows will say that these things are just earth and stones, and are incapable of caring for human affairs, however much our plausible rhetoric has managed to dress them up. (886d)

In any case, Plato finds that the teaching of astronomy is socially necessary. Even if he systematically ignored the fact that four seasons are unequal in length, as discovered some 50 years before by Meton and Euktemon (Dreyer, 1953), he could not disregard the early tradition of the Greek astronomy, including Hesiod's *Works and Days* (Goldstein, & Bowen, 1983), as well as the importance of calendars for the society. Thus, his anonymous Athenian explains how astronomy can provide the means for the temporal definition of events which mark communal life in a state: "Every year after the summer solstice the entire state should congregate in a precinct dedicated jointly to Apollo and the Sun ..." (946a)

In the same spirit he states "... on the day just before the new year opens in the month after the summer solstice; ..." (767c), and

> But how will the law itself adequately convey its teaching ... for the same reasons they must acquire such knowledge about the heavenly bodies in their courses – sun, moon and stars – as will help them with the arrangements that every state is forced to make in this respect. You ask what arrangements we are referring to? We mean that the days must be grouped into months, and the months into years, in such a way that the seasons, along with their various sacrifices and festivals, may each receive proper recognition by being duly observed in their natural sequence. (809b)

along with

> Now then, the next job is to ... draw up a programme of festivals to be established by law ... to decide the number and the occasions, ... There are to be no less than three hundred and sixty-five of them, so as to ensure that there is always at least one official sacrificing to some god ... (828a)

and, finally: "... before the rising of Arcturus ushers in the vintage ... " (844e)

Therefore, schools should teach Logic, Mathematics and "... the mutual relationship of the heavenly bodies as they revolve in their courses. ..." (817e) since:

> A man, at any rate, will fall a long way short of such godlike standards ... if he ... can't reckon up the days and the nights, and is ignorant of the revolutions of the sun and moon and the other heavenly bodies. (818c)

3 PLATO'S TIMES

Plato's educational model stems from Egypt, stated also in (819b-e), where temples were the centres of learning, encompassing both primary schools, where children learned reading and writing, divine history, state organization, arithmetic, history, and geography, as well as secondary schools or technical schools where the young became sculptors, draughtsmen, or engravers serving the needs of the kingdom (Montet 1988).

This was quite contrary to Athenian practice where schools were private. Children, meaning boys only of course, were taught reading, writing, arithmetic, music and at a later age gymnastics (Flaceliere, 1971). The knowledge offered by these schools was rudimentary. Yet, the time span between the end of the Persian Wars and the defeat of Athens in the hands of Sparta was a particularly creative one for the arts and sciences and witnessed quite a few educational changes. The first such reform was brought about by the sophists, offering for a generous fee their knowledge of geometry, physics, astronomy, the arts, rhetoric, and philosophy.

At the same time, a number of wise men, among whom Anaxagoras, Zeno, and Democritus came to Athens to satisfy the demands of a public hungry for new ideas. This thirst for learning resulted in the creation of institutions of higher learning: Plato founded the Academy on the Pythagorean model in 387 BC, Aristotle the Peripatetic school, Isocrates his school of rhetoric and philosophy, advocating views contrary to those of the Academy; many smaller schools founded by less renowned teachers would follow.

This was an age characterized by intellectual self-confidence: man felt mature and ready to study nature and discover the laws that define and determine the universe.

It is worthwhile making a brief digression here: it has often been claimed that the sciences in Greece were directly derived from their counterparts in Egypt and Babylonia. It is true that the Greeks took over elements of these earlier civilizations: an example is that of reciprocals – fractions with a numerator equal to one – which formed the basis of non-integer arithmetic in Athens; these were already in use in Egypt a thousand years before the time of Pericles and in fact remained in use under the Romans and into the Middle Ages. However, before the Greeks, the sciences were

characterized by their practical spirit; knowledge was oriented to specific applications, problems did not encounter a general statement, exact methods and results were confused with approximative ones. All this was in complete contradiction to the characteristics of Greek science (Boyer, 1985).

Thus, despite the multifarious intellectual searches of his time, Plato remains loyal to the theocratic, utilitarian, and static Egyptian model, according to which even music should be devoted to the gods so that any musical innovation can be considered an affront to the gods, worthy of punishment (799-800b). Moreover, the acquisition of knowledge in the authoritarian and strictly controlled society that Plato proposes (689e-690e) is not the right of every citizen: "None of these subjects must be studied in minute detail by the general public, but only by a chosen few." (818a)

4 THE ROLE OF THE SENSES IN PERCEPTION

For Plato, Knowledge is remembrance rather than sensation, to be achieved through mystical contemplation and intuition and not through the senses (Russell, 1972). The senses only lead human beings to illusions:

> ATHENIAN: My dear fellows, at the present day nearly all we Greeks do the great gods – Sun and Moon – an injustice.
> CLEINIAS: How so?
> ATHENIAN: We say that they, and certain other heavenly bodies with them, never follow the same path. Hence our name for them: 'planets'.
> CLEINIAS: Good heavens, sir, that's absolutely right. In the course of my life I've often seen with my own eyes how the Morning and the Evening Star, and a number of others, never describe the same course, but vary from one to another; and we all know that the sun and moon always move like that. (821bc)

Cleinias had already remarked that the orbit of Venus around the earth was "irregular". Moreover, irregularities are in the Platonic view synonymous with evil (897cd), see also in Boodin (1930) and Meldrum (1950). Thus, Plato's disciples, Eudoxus and, a little later Callippos, resolved the Sun's orbit, as well as the orbits of the other planets, into thirty circular "regular" motions, in accordance with the precepts of Plato (Goldstein, & Bowen, 1983; Neugebauer, 1957). Whether Plato was, or was not aware of the work by Eudoxus when he was writing *The Laws*, or, even, whether it was he who initiated and suggested this work in order to "save the phenomena", that is to show the regularity of the motions of the planets, has been the issue of many discussions that can be traced for example in Knorr (1990), Mittelstrass (1962), Mourelatos (1981), and Vlastos (1980).

The thirty regular circular motions in the analysis of Eudoxus and Calippos were inadequate for the description of the planets' orbits, but it is well known today that any periodic orbital motion – in general any variation of a closed orbit – can be satisfactorily accounted for by a – possibly infinite – sum of regular circular motions. We thus come across the first analysis of movement in the history of the sciences (Palter, 1970) that is very similar to the analysis in Fourier series; all this due to Plato's theory of the universe according to which the planets, being ideal beings, followed "perfect" circular orbits!

It is worth noting here that the theoretical model of Eudoxus was constructed by the Italian astronomer Schiaparelli, 1835-1910, (Mourelatos, 1981), which demonstrated the failure of the Eudoxean model to describe the relevant celestial motions. However, the failure of a model created 23 centuries ago does not diminish the importance of the work of Eudoxus in the evolution of astronomy.

5 SOPHISTS AND PHYSICAL PHILOSOPHERS

One of the major issues for philosophical debate influencing political life in Plato's time concerned the confrontation between law and nature fuelled by the teachings of the natural philosophers and the sophists. Plato did not directly take position in this debate (Ostwald, 1977), but his work describes clearly his ideas: the laws proposed in *The Laws* by the Athenian govern even the motion of the planets, contrary to everyday experience though this must seem:

> This belief ... that the moon and sun and other heavenly bodies do in fact 'wander', is incorrect: precisely the opposite is true. Actually, each of them perpetually describes just one fixed orbit, although it is true that to all appearances its path is always changing. Further, the quickest body is wrongly supposed to be the slowest and vice versa. (822abc)

The tenth book of *The Laws* gives an explanation of Plato's theological astronomy. All those referred to below are not only wrong but also guilty of impiety before the gods:

> Some people, I believe, account for all things which have come to exist, all things which are coming into existence now, and all things which will do so in the future, by attributing them either to nature, art, or chance. (888e)

He is in fact referring to the Ionian physical philosophers, the first ones attempting an explanation of natural phenomena without recourse to metaphysical notions, a full two centuries before Plato. They are his ideological opponents, just like the sophists, critical of established ideas (Boyer, 1985). Plato goes on to refer to them in the following terms:

> The facts show – so they claim – that the greatest and finest things in the world are the products of nature and chance, the creations of art being comparatively trivial ... They maintain that fire, water, earth and air owe their existence to nature and chance, and in no case to art, and that it is by means of these entirely inanimate substances that the secondary physical bodies – the earth, sun, moon and stars – have been produced. These substances moved at random, each impelled by virtue of its own inherent properties, which depended on various suitable amalgamations of hot and cold, dry and wet, soft and hard, and all the other haphazard combinations that inevitably resulted when the opposites were mixed. This is the process to which all the heavens and everything that is in them owe their birth, and the consequent establishment of the four seasons led to the appearance of all plants and living creatures. The cause of all this, they say, was neither intelligent planning, nor a deity, nor art, but – as we've explained – nature and chance. (889cd)

And Plato explains why he fights against such ideas originating in the sophists and the physical philosophers:

> All this, my friends, is the theme of experts – as our young people regard them – who in their prose and poetry maintain that anything one can get away with by force is absolutely justified. This is why we experience outbreaks of impiety among the young, who assume that the kind of gods the law tells them to believe in do not exist; this is why we get treasonable efforts to convert people to the 'true natural life', which is essentially nothing but a life of conquest over others, not one of service to your neighbour as the law enjoins. (890a)

According to Plato, nature has no moral values and the acceptance of natural laws would damage social life (see also Ostwald, 1977; Solmsen, 1977). Furthermore,

natural phenomena should exhibit ethical and aesthetical order (Goldstein, & Bowen, 1983). This is why he advises the young to turn a deaf ear to teachings purporting to modify their early, childhood beliefs about the gods, as in due time they are bound to return to them (888b). Traditionally, all are taught from an early age to believe in the gods and pray to them:

> At the rising and setting of the sun and moon the children saw and heard Greeks and foreigners, in happiness and misery alike, all prostrate at their devotions; far from supposing gods to be a myth, the worshippers believed their existence to be so sure as to be beyond suspicion. (887d)

6 THE NATURE OF THE STARS

Plato then (891c-893e) goes on to discuss the nature of stars. This analysis revolves around the role of the soul: "It is one of the *first* creations, born long before all physical things, and is the chief cause of all their alterations and transformations."(892ac)

Since "... the definition of the thing we call the soul: ... 'motion capable of moving itself' ... " (895a-896a), from the definition of what constitutes being:

> This is then the process of change and alteration to which everything owes its birth. A thing exists as such as long as it is stable, but when it changes its essential state it is completely destroyed. (894b)

Plato infers that change destroys being. This is significant: the Platonic world, contrary to that of the Ionian philosophers has no space for "becoming", only "being" (Sinachopoulos & Sinachopoulos, 1991). This destruction of being through change leads Plato to conclude:

> Well then, what kind of soul may we say has gained control of the heavens and earth and their entire cycle of movement? ... If ... the whole course and movement of the heavens and all that is in them reflect the motion and revolution and calculation of reason, and operate in a corresponding fashion, then clearly we have to admit that it is the best kind of soul that cares for the entire universe and directs it along the best path. (897c)

In the next (898c) and subsequent paragraphs, he expresses a world view in fundamental contradiction to that of the view of the natural philosophers:

> ... since we find that the entire cycle of events is to be attributed to soul, the heavens that we see revolving must necessarily be driven round ... because they are arranged and directed *either* by the best kind of soul *or* by the other sort. ...
>
> If, in principle, soul drives round the sun, moon and the other heavenly bodies, does it not impel each individually? ... Whether we find that it is by stationing itself in the sun and driving it like a chariot, or by moving it from outside, or by some other means, that this soul provides us all with light, every single one of us is bound to regard it as a god. Isn't that right? (898c)

Thus, for the first time in human history, and using an astronomical model as a tool, a 'proof' of the existence of gods is given, the worship of divinity appears in philosophy and Plato can claim to be the founder of philosophic theology (Taylor, 1978). As Zeller and Nestle (1980) explain:

> It was through Pythagoreanism that he [Plato] obtained his knowledge of two sciences which were appropriate to his idealistic system and at the same time formed a link between the world of the mind and the world of matter.

> Mathematics taught what was eternal in the earthly and perceived the supersensual in the material, while astronomy turned the gaze from the earth and directed it into the depths of the universe to those mysterious celestial bodies which move of movements are ordered by number and by measure and can be comprehended by the thinking mind. Mathematics of course was only 'a ferment in Plato's mysticism' and the star gods strictly speaking belonged to the heavenly world.

This observation makes it easier to understand Plato's assertions such as the following:

> Now consider all the stars and the moon and the years and months and all the seasons: what can we do except repeat the same story? A soul or souls – and perfectly virtuous souls at that – have been shown to be the cause of all these phenomena, and whether it is by their living presence ... we shall insist that these souls are gods. (899b)

His astronomical system now completed, Plato proceeds to sum it up:

> Now then, ... let's delimit the courses of action open to anyone who has so far refused to believe in gods, and get rid of him ... *either* he should demonstrate to us that we're wrong to posit soul as the first cause to which everything owes its birth, and that our subsequent deductions were equally mistaken, *or*, if he can't put a better case than ours, he should let himself be persuaded by us and live the rest of his life a believer in gods. (899c)

Plato thus considers astronomy and, by extension, physics in a completely theological and metaphysical spirit, convinced that everything that exists in the world has to be "ideal", in vindication of his world view (Dreyer, 1953; Russell, 1972; Taylor, 1978). Furthermore, his disdain of perceptual experience (Lloyd, 1968) and his belief that nature, being in a state of permanent flux, is not knowable (Ostwald, 1977) lead him to the position that nature cannot be the object of science (Mittelstrass, 1962). His spirit was contrary to observation and experiment (Goldstein & Bowen, 1983), this being probably his only point of disagreement with the Pythagoreans (Vlastos, 1980; Zeller & Nestle, 1980) who had used experiment in developing the theory of harmonics.

7 EPILOGUE TO *THE LAWS*

Plato returns to astronomy in the closing paragraphs of *The Laws* (966e) to emphasize once again how dangerous the teachings of the physical philosophers are, as they lead to atheism:

> Now we know, don't we, that among the arguments we've already discussed, there are two in particular which encourage belief in the gods? ... One is the point we made about the soul, when we argued that it is far older and far more divine than all those things whose movements have sprung up and provided the impulse which has plunged it into a perpetual stream of existence. Another argument was based on the systematic motion of the heavenly bodies and the other objects under the control of reason, which is responsible for the order in the universe. (966e)
>
> No one who has contemplated all this with a careful and expert eye has in fact ever degenerated into such ungodliness as to reach the position that most people would expect him to reach. They suppose that if a man goes in for such things as astronomy and the essential associated disciplines, and sees events apparently happening by necessity rather than because they are directed by the intention of a benevolent will, he'll turn into an atheist.

> ... [Some thinkers] concluded from the evidence of their eyes that all the bodies that move across the heavens were mere collections of stone and earth and many other kinds of inanimate matter – inanimate matter which nevertheless initiated a chain of causation responsible for all the order in the universe. Such conclusions led to a variety of atheistic and unpopular doctrines taking hold of these philosophers' minds; ... (966e-967d)

One has to conclude that in *The Laws*, Plato, great thinker that his admirers may consider him to be (Boyer, 1985), not only offers nothing to further the progress of astronomy, but in fact discourages its study.

8 DISCUSSION

Plato's cosmological considerations presented in *The Laws* do not fully agree with those manifested in *Timaeus* (Plato2), see also Boodin (1930), Hackforth (1959), Meldrum (1950). *Timaeus* delineates the genesis of the world, including the creation of a world soul, the stars (considered as celestial gods), the beginning of the cosmic time, and, also, the formation of the human beings, the animals and the plants. It is a Demiourgos, a Creator, who methodically created Cosmos, soul and life, and this creation has been achieved in the best way, while a second cosmic power, Necessity, governs the material aspects of the world.

The lack of complete agreement in the concepts and principles between *The Laws*, in which the soul is the origin of motion, and *Timaeus*, with the metaphysical Creator, legitimates the discussion of whether we should consider the entire Platonic work as one coherent whole, and, consequently, of whether we should expect consistency between the various Platonic strands. It is a common practice of many Platonists, for example Vlastos (1980), to use concepts of one Platonic work in order to smooth what amounts, in their opinion, to uneven points in some other work. However, the justification of such extrapolations is questionable, since knowledge and ideas evolve with time and age; there is no indication that Plato himself intended to consolidate his work in that sense. More about the issue of consistency in the entire Platonic work can be found for example in Meldrum (1950), Ostwald (1977), and Turnbull (1980).

Some scientists feel the need to restore Plato in the history of scientific thought (see e.g. Anton, 1980). Nevertheless, Plato's work hardly needs rehabilitation: its worth does not necessarily lie in his conception of astronomy or of science in general, but in the simple, everyday way he talked about the most important issues of politics, issues that are still important and under debate in our time, and about the whole spectrum of knowledge in his time. More about the originality of his teaching regarding natural sciences can be found in (Lloyd, 1968 and Mueller, 1980). Anyhow, it would be too easy to use the advantage of our age and our contemporary view of sciences to criticize work done 2400 years earlier (Mourelatos, 1981; Sinachopoulos & Sinachopoulos, 1991). What, however, remains important, and we consider it as our duty, is to become acquainted with Platonic doctrines, to attempt to understand them in the context of his time and to form our own opinion of Plato, of the evolution of science, and, even, of scientific understanding in our times.

The political positions of Plato have not often been related to his views on natural science and astronomy. Plato was a deep political thinker - disregarding the fact that we may dislike his political convictions - and his main concern in *The Laws* –and in *The Republic* and, also, *Timaeus*, as explained in the first part of *Timaeus*, – is how to rule society in the most appropriate and effective way. Natural sciences and astronomy are important to Plato only as far as they can contribute to good government, law and order. He was not concerned with science *an sich* or with theology or astronomy (Boodin, 1929; Meldrum, 1950; Mittelstrass, 1962; Solmsen, 1977). His intentions have been clearly expounded in *The Laws*, as well as in *The*

Republic: these works deal with politics and ruling. As regards cosmogony and nature, some well-narrated myths can answer all general questions about the world (Callahan, 1977), and help the rulers govern a compliant populace.

It is a regret that some important scientists who have understood well the political aspects and conclusions of Plato's work, for example Vlastos (1977), were never perceptive enough to evaluate Platonic concepts about the natural sciences in the framework of his political principles.

Yet, we cannot blame Plato for the use made of his teachings regarding astronomy and natural sciences. Through the centuries it has been convenient to deal with astronomy in the Platonic sense (Callahan, 1977; Kalfas, 1990; Mourelatos, 1981; Mueller, 1980; Solmsen, 1977; Turnbull, 1980) either because of the lack of accurate observational means, or because of religious doctrine, or, simply, because the times were not mature enough for an astronomy directly related to what happens in the skies.

It is impressive that the old confrontation between the Platonic and Aristotelian way of thinking – simplifying: theorisation, stability, and symmetry versus experience, change, and complexity (see also Donnay, 1960) – remains alive in our time, for example Barrow (1991). This may be an additional reason to go back to the roots of the relevant debates in order to arrive at a better understanding of the evolution of the natural sciences and of the factors that influenced this evolution.

9 AFTERWORD

In the introduction of the *Almagest*, a few centuries later, Ptolemy describes astronomy as the branch of knowledge dealing with the divine and heavenly bodies, adding that this is a science concerned with the study of an eternal, immutable world. Thus Ptolemy, through his belief in the Platonic model of a static and non-evolving universe, as well as his conviction that the planets are "divine bodies", is not particularly concerned with observation, though he states the contrary, neither when he compiles his star catalogue, partially copied from that of Hipparchus, or perhaps not, see e.g. in van der Waerden (1988) and Palter (1970), nor when it comes to determining the inclination of the ecliptic, which he has probably obtained from the work of Eratosthenes (van der Waerden 1988).

Thus, three hundred years after Plato, hostility towards observation had already led to disastrous results. For example, in the fifth century AD the Alexandrian explorer - and, necessarily, with a deep astronomical knowledge - Kosmas sailed from Alexandria to the Indian Ocean - hence his surname Indicopleustis -. According to him, God created a flat and not a spherical Earth. However, Dreyer (1953) points out that "As he [Kosmas] must have reached places within ten degrees of the equator, it is very remarkable that he could be blind to the fact that the earth is a sphere."

Many centuries would have to pass before a critical view of the world became possible, permitting us to try to comprehend natural laws without any metaphysical preconceptions. As Farrington (1963) remarks, "Not till the time of Kepler did astronomy rid itself of the necessity of interpreting the behaviour of the planets in terms of the social prejudices of the Pythagoreans."

10 NOTES

1. All numbers cited are references to paragraphs in *The Laws* except (Rep 530b) which refers to Plato's *The Republic*.
2. We have intentionally avoided any mention to the *Epinomis* here, which is not considered a work of Plato (e.g. Knorr, 1990), and thus should not be appended to *The Laws*, as is sometimes done for historical reasons. The *Epinomis*, probably the work of Philip of Opundium, disciple of Plato (Zeller & Nestle 1980), is a work of particular astronomical interest, where it is claimed that Mathematics and Astronomy provide the highest form of knowledge.

3. The following table contains essentially all points in *The Laws* that are directly or indirectly of astronomical interest.

11 TABLE OF PARAGRAPHS WITH ASTRONOMICAL INTEREST IN *THE LAWS*

641c	653c	677a	714e	767c	771b	809b
818a	818c	819bcd	821bc	822abc	828a	844e
886ac	886d	887d	888b	888e	889cd	890a
890d	891c	892ac	893bc	893de	894abc	894de
895abc	895de	896abc	898c-899d	946a	960d	966e

12 ACKNOWLEDGEMENTS

We heartily thank Panayotis Mouzourakis for the (not always tranquil) discussions on Plato and his world. We are also most grateful to Dr Alan Batten for his constructive criticism and suggestions, which led to a significant broadening of the scope and the depth of the article initially submitted.

13 REFERENCES

Anton, J.P., 1980. Introduction. In J.P. Anton (editor), *Science and the Sciences in Plato*. EIDOS, New York, pp. ix-xv.

Barrow, J., 1991. Platonic relationships in the universe? *New Scientist*, 20 April 1991, pp. 40-43.

Boodin, J.E., 1929. Cosmology in Plato's Thought, I. *Mind*, **38**:489-505.

Boodin, J.E., 1930. Cosmology in Plato's Thought, II. *Mind*, **39**:61-78.

Boyer, C., 1985. *A History of Mathematics*. Princeton University Press, Princeton, N.J.

Bulmer-Thomas, I., 1984. Plato's Astronomy. *Classical Quarterly*, **34**:107-112.

Callahan, J., 1977. Dialectic, Myth and History in the Philosophy of Plato. In H. North (editor), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 64-79.

Donnay, G., 1960. Le système astronomique de Platon. *Revue Belge de Philologie et d'Histoire*, **38**: 5-29.

Dreyer, J.L.E., 1953. *A History of Astronomy from Thales to Kepler*, Revised with a Foreword by W.H. Stahl. Dover Publications, New York. First edition published in 1906.

Farrington, B., 1963. *Greek Science and its Meaning for us*. Pelican Books, London. First edition published in 1944.

Flaceliere, R., 1971. *La vie quotidienne en Grèce au siecle de Pericles*. Librairie Hachette, Paris.

Goldstein B.R. and Bowen A.C., 1983. A new view of early Greek Astronomy. *Isis*, **LXXIV**:330-340.

Hackforth R., 1959. Plato's cosmogony (Timaeus 27d ff). *Classical Quarterly*, **53**:17-22.

Kalfas, V., 1990. Criteria for the birth of a new science: The case of Greek Astronomy. In P. Nicolakopoulos (ed.), *Greek Studies in the History and Philosophy of Science*, Dordrecht, pp. 171-185.

Knorr, W.R., 1990. Plato and Eudoxus on the planetary motions. *Journal for the History of Astronomy* **21**:313-329.

Lloyd, G.E.R., 1968. Plato as a natural scientist. *Journal of Hellenic Studies*, **88**:78-92.

Meldrum, M., 1950. Plato and the αρχη κακων. *Journal of Hellenic Studies*, **LXX**:65-74.

Mittelstrass, J., 1962. Die Rettung der Phaenomene, *Ursprung und Geschichte eines antiken Forschungsprinzips*. Walter de Gruyer and Co., Berlin.

Montet, P., 1988. *La vie quotidienne en Egypte au temps de Ramses*. Librairie Hachette, Paris.

Mourelatos, A.P.D., 1980. Plato's "Real Astronomy": Republic VII 527D-531D. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 33-74.

Mourelatos, A.P.D., 1981. Astronomy and Kinematics in Plato's Project of Rationalist Explanation. *Studies in History and Philosophy of Science*, **12**:1-32.

Mueller, J, 1980. Ascending to problems: Astronomy and harmonics in Republic VII. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 103-121.

Neugebauer, O., 1957. *The Exact Sciences in Antiquity*. Providence, Brown University Press. First edition published in 1952.

Ostwald, M., 1977. Plato on Law and Nature. In H. North (ed.), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 41-63.

Palter, R., 1970. An approach to the history of early astronomy. *Studies in History and Philosophy of Science*, **1**:93-132.

Plato1. *The Republic*. Translated with an introduction by Desmond Lee. Penguin Classics London, 1987. First edition 1955.

Plato2. *Timaios*. Translated with an introduction by Kalfas Vasilis. Polis, Athens (in Greek), 1995. (ISBN: 960-7478-11-8)

Plato3. *The Laws*. Translated with an introduction by Trevor Saunders. Penguin Classics, Harmondsworth, Middlesex, 1970.

Russell, B., 1972. *A History of Western Philosophy*. Simon and Schuster, New York. First edition in 1946.

Sinachopoulos, A. and Sinachopoulos, D., 1991. The Teaching of Astronomy in Plato's Republic. *The Astronomy Quarterly*, **8**:181-187.

Solmsen, F., 1977. Plato and Science. In H. North (ed.), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 86-105.

Taylor, A.E., 1978. *Plato, The Man and his Work*. Methuen and Co. Ltd., London. First edition in 1926.

Turnbull, R.G., 1980. The later platonic concept of scientific explanation. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 75-101.

van der Waerden, B.L., 1988. *Die Astronomie der Griechen, Eine Einfürung*. Darmstadt, Wissentschaftliche Buchgesellschaft.

Vlastos, G., 1977. The theory of social justice in the *Polis* in Plato's Republic. In H. North (ed.), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 1-40.

Vlastos, G., 1980. The role of observation in Plato's conception of astronomy. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 1-31.

Zeller, E. and Nestle, W., 1980. *Outlines of the History of Greek Philosophy*. New York, Dover. First edition of the original the work by Zeller in 1883.

Aneta Sinachopoulos is with the Université Libre de Bruxelles, the Free University of Brussels. She works on Formal Methods, the use of logics in information technologies and the history of sciences.

Dimitris Sinachopoulos works at the Astronomical Institute of the National Observatory of Athens. He is active in astrophysics of stellar evolution and gravitational lensing as well as in the history of astronomy.