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THE LEGITIMATION OF SCIENTIFIC BELIEF THEORY JUSTIFICATION BY COPERNICUS*

One of the most important and enduring philosophical issues in the history of science has been the purpose and status of scientific theories. It is an issue with a long history; but in this modern form it can be traced back to the publication of Copernicus' major work, *De revolutionibus orbium coelestium* (1543). The appearance of that work generated a continuing controversy, both by the nature of its central claim—terrestrial mobility—and by the discrepancy between Copernicus' novel claim for the *truth* of his theory and the then prevailing view of the hypothetical nature of all such theories. The latter point of view was expressed in the anonymous letter to the reader prefixed to the beginning of the printed work by its editor, Andreas Osiander. [1] Between these two points of view about the status of scientific theories lies the root of the modern Realist-Instrumentalist debate and the more recent discussions concerning the rationality of scientific theories.

It is not my intention here to attempt a resolution of those issues, nor even to survey their recent history. [2] My purpose, rather, is to explore an important issue arising from those discussions of Copernicus'

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[1] On Osiander's involvement with Copernicus, see my *Andreas Osiander's Contribution to the Copernican Achievement* in: R.S. Westman (ed.), *The Copernican Achievement*, Los Angeles, 1975.

[2] A good survey of the issue may be found in A. Musgrave and I. Lakatos, *Criticism and the Growth of Knowledge*, Cambridge, 1970, and in F. Suppe, *The Structure of Scientific Theories*, (2nd ed.), Urbana, 1977.

work but often neglected in appraising it, that relates to the concern of this conference: namely, the process by which Copernicus conceived of and came to believe in the reality of terrestrial motion and the way he justified that belief. In short: the Copernican "discovery." [3]

Let me begin by stating the philosophical problem that confronted Copernicus which has engaged modern attention and show its bearing on the question of discovery: Given (a) two competing scientific theories such as the Ptolemaic and the Copernican, both of which represent observational data equally well and yield equally reliable predictions, and given (b) the fact that the novel Copernican theory flatly contradicted accepted physical principles as well as conventional beliefs and sacred scripture, all of which justified its rival; how, then, could one decide which of these two theories is correct? More important for my purposes is the question: how did Copernicus decide? His assertion of the truth of his theory could not be based upon conventional methodological principles since such principles only served to falsify his claim. Nor did there exist before the 19th century any conclusive factual support by which to settle the matter. [4] This leads to the central issue confronting Copernicus: what will justify "the assertion of an unsupported conjecture in the face of fact and well-supported contrary conjectures?"

P. K. Feyerabend answered that question by insisting that acceptance of the new theory can only be based on "metaphysical belief." The position of Thomas Kuhn is better known but causes similir visceral discomfort to his critics. He argues that the decision is a *choice* between rival paradigms and cannot be resolved by criteria that are entirely theory--neutral or value-free. What motivates the choice of the novel theory therefore is a kind of "conversion" experience. Kuhn's critics have strenuously criticized this aspect of his work, insisting that if there are no theory-neutral criteria of scientific judgement, no common methodological standards available for selection between competing theories, the decision becomes arbitrary and subjective, a kind of "religious change" that is "irrational" and a matter of "mob psychology." [5] To such critics, the admission of these elements into the appraisal of theories threatens the very rationality of the scientific enterprise. Kuhn's position thus

[3] I use the word "discovery" in a qualified way since Copernicus, of course, did not discover terrestrial mobility.

[4] Bessell discovered stellar parallax in 1818. Galileo observed the phases of Venus in 1616 which are predicted by Copernicus' theory, but that has no bearing on his discovery or his own justification of it.

[5] *Criticism and the Growth of Knowledge*, pp. 33, 56–57, 93–118. Feyerabend's views are summarized in his *Problems of Empiricism* in R. Colodny, *Beyond the Edge of Certainty*, 1965.

seems to confirm what positivists have always maintained: that theories are mere "instruments" of computation and prediction without explanatory power and that one can rationally reconstruct and appraise a theory only in terms of its testable implications. The generation of a scientific theory, therefore, is not a part of the scientific process itself since it is fundamentally irrational. Hence, there has arised the sharp distinction between the "context of justification" and the "context of discovery" with the former, alone, deemed suitable for logical and rational analysis and the latter relegated to the dumping ground of the emotive. [6]

It is my contention that this distinction is false, value-loaded and inimical to a rational understanding of scientific progress. To ask for those considerations that persuaded Copernicus and led him to assert the truth of a new theory in defiance of formidable falsifying arguments, is not to ask for a description of psychological states but for those *reasons* and *arguments* by which he advanced from theory inception to completion. It shall be my purpose in this paper to demonstrate the logical "pattern of discovery" [7] in Copernicus' work by showing the process by which he conceived, formulated, justified and thus, came to believe in assert the truth of his theory.

Let me begin the exploration of that process by asking, what motivated Copernicus' search for an alternative theory. What raised doubts in his mind about the credibility of the prevailing Ptolemaic view and what aims in science did he entertain that led those dissatisfactions to undermine his belief in its validity and motivated his life-long search for a *true* system of the universe?

Historians typically pointed to the problem of the calendar and the urgent need for its reform as the source of their dissatisfaction. Jerome Ravetz, for example, recently argued the case that Copernicus, like every other astronomer, knew that the calendar was hopelessly inaccurate and that dates calculated on the basis of the Alphonsine tables bore little relationship to the observed motions of sun and moon. [8] And because of the complexities of observed motion, calendaric reform was not possible without a better theoretical basis, for the laws of motion and the prevailing theories either failed to account for observed motions or could not explain those motions. Thus (according to Ravetz), Copernicus was promoted to search for a theory that would accomplish both

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[6] This distinction was first formulated by H. Reichenbach in his *The Rise of Scientific Philosophy*, Berkeley, 1958.

[7] From the title of N. R. Hanson, *Patterns of Discovery*, Cambridge, 1961.

[8] J. Ravetz, *The Origin of the Copernican Revolution*, "Scientific American" 236 (1977), pp. 88–98.

demands and would provide the needed basis for calendar reform. He then concludes: "Copernicus failed to set down clearly and concisely what made him believe the earth really rotates in orbit around the sun." And further: "To ask ... 'whence came the marvelous insight that showed him the truth' is to invite no answer or a purely speculative one."

But the source of that insight is not at all mysterious; in Book I and in the dedicatory letter to Pope Paul, Copernicus clearly describes the source of his "insight" and the concerns by which he was led to search for a more "reasonable" alternative and to adopt the assumption of terrestrial mobility. But he has almost nothing to say in those places about calendar reform.[9] What he *does* say there is that the unsatisfactory state of astronomy led him to search for alternative views among the writings of the ancients and in such writings he learned of Pythagorean teachings about the motion of the earth.[10] By the time of the Fifth Lateran Council (1512-1517) which undertook the task of reforming the calendar, Copernicus had already formulated the basic principles of his system. The result of those early investigations—the *Commentariolus*—written between 1510 and 1514, contains the postulate of terrestrial motion as his sixth assumption.[11]

It is clear then that Copernicus' search for principles by which to rennovate astronomy did not derive from the need for calendar reform but, as he tells us, because of the fundamental inconsistency in Ptolemy with the principle of absolute motion. The concern was philosophical, not practical. Ptolemy's *Almagest* accounted for the observed phenomena well enough: but it did so only by contradicting the cardinal physical principle of uniform circular rotation. The Eudoxian-Aristo-

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[9] At most, the reform initiated by the council and coordinated by Paul of Middelburg gave additional impetus to the investigations he already had in progress. His *Commentariolus* appeared before the report of Paul to Leo X was issued, in which Paul reports receiving an opinion from Copernicus. Copernicus refers to this briefly near the end of his letter of dedication.

[10] Contrary to E. Rosen, I do not believe Copernicus differentiates his position from the Pythagorean belief in a moving earth. What he says is, "Let no one suppose that I have gratuitously [i.e., rashly or without reasons] assumed, with the Pythagoreans, the motion of the earth ..." That this is not a disassociation of his belief from theirs, as Rosen believes, is supported by the places in the *Revolutions* where he clearly states his indebtedness to them for their ideas of terrestrial mobility, and not just for their policy of private disclosure. For example, the passage in the middle of the dedication and two separate references in Book I, Chapter 5.

[11] Rosen in *Three Copernican Treatises*, (3rd ed.) has convincingly documented the beginning of Copernicus' doubts about Ptolemy which started as early as 1496–1501 in Bologna when, as a student he assisted the astronomer Novara, who publically demonstrated inaccuracies in latitudinal figures in Ptolemy's *Geography*, indicating that the earth may not be motionless. He was also familiar with Regiomontanus' *Epitome* (1496) and his criticisms of Ptolemy's lunar theory, criticisms which are reflected in Copernicus' earliest astronomical writing, the *Commentariolus*.

telian scheme of homocentric spheres, while consistent with that principle, could not satisfactorily account for the phenomena. For these reasons astronomical hypotheses throughout the Middle Ages were regarded as just that: merely hypothetical. Osiander's letter thus represented the generally prevalent skepticism about the status of astronomical theories, as well as his own theological convictions that *truth* could be known only by divine revelation.

It is precisely on those grounds that Copernicus departs from the traditional conception of the task of astronomy and asserts the truth of his theory: it is his belief in the intelligibility of the universe as a revelation of God that informs his conception of science as the search to discover truth. This belief, anterior to all his dissatisfactions with prevailing theories, was the primary motivator of his demand for consistency of theory and data with physical and metaphysical principles. It was the starting point for his life-long search for a true system of the universe.

These convictions were present very early in his investigations. As early as the *Commentariolus*, Copernicus wrote:

> "The planetary theories of Ptolemy and most other astronomers, although consistent with the numerical data, seemed likewise to present no small difficulty. For these theories were not adequate unless certain equants were also conceived; it then appeared that a planet moved with uniform velocity neither on its deferent nor about the center of its epicycle. Hence a system of this sort seemed neither sufficiently absolute nor sufficiently pleasing to the mind.
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> Having become aware of these defects, I often considered whether there could perhaps be found a more reasonable arrangement of circles, from which every apparent inequality would be derived and in which everything would move uniformly about its proper center, as the rule of absolute motion requires. After I had addressed myself to this very difficult and almost insoluble problem, the suggestion at length came to me how it could be solved with fewer and much simpler constructions than were formerly used, if some assumptions (which are called axioms) were granted me."

Then, after listing the seven assumptions on which his system is based, including the all-important sixth assumption of terrestrial motion, he adds:

> "Accordingly, let no one suppose that I have gratuitously asserted, with the Pythagoreans, the motion of the earth; strong proof will be found in may exposition of the circles. For the principal arguments by which the natural philosophers attempt to establish the immobility of the earth rest for the most part on appearances; it is particularly such arguments that collapse here, since I treat the earth's immobility as due to an appearance."

When his major work finally appeared in 1543 containing that "strong proof," the concern for consistency was still uppermost in his mind. In the letter of dedication, Copernicus points specifically

to that lack of consistency in prevailing theories and to the subsequent necessity of constructing *ad hoc* devices like the equant to preserve the fiction of uniform motion. This expedient not only violated the rule of motion but was offensive to Copernicus' demand for a *true* theory. The resulting system, he said, was an absurdity:

> "It is as if in his picture, an artist were to bring together hands, feet, head and other limbs from quite different models without a common relationship to a single body. The result would be a monster, not a man."

Since the prevailing theory was therefore no system at all, lacking any common, unifying principle of motion, to assert the reality of *that* theory would be to make a mockery of reason and faith. For Copernicus could not believe that the God whom he affirmed in *De Revolutionibus* as the "universal Artisan of all things" and the "Best and Most Orderly Workman" would be so clumsy as to have created such a monstrosity.[12] It was thus on the basis of his belief in creator God who was the "Best and Greatest Artist" that he sought for "purer and more convenient assumptions" that would be consistent with the principle of uniform motion.

It is in just these places where the demand for unity, simplicity, necessity, and consistency, is expressed that Copernicus discloses the underlying beliefs that propelled his search and the criteria by which he judged the validity of rival theories and validated his own. On the surface, such criteria appear only as aesthetic values; but for a philosophically-minded Christian astronomer thoroughly trained in the doctrines of Aristotle, such criteria had physical and metaphysical significance whereby they functioned as criteria to judge the validity of theories. For Copernicus the study of the universe could never be reduced to mere technical astronomy; cosmology was also physics (philosophy) and metaphysics or, in Aristotle's word, *theology*. Thus, to reduce the diverse motions of celestial bodies to a single, unifying theory in which all the component parts become so inter-dependent as to establish the necessity of their observed motions, becomes a necessary condition for a theory to be true. Those criteria commended themselves to Copernicus not simply on aesthetic grounds but because those qualities were intimately related to his Christian beliefs about the unity, wisdom and power of God, whose creation reflects these very qualities of its creator.

Behind such beliefs stands a long tradition of Christian speculation

[12] These references to divine revelation are found in two places in the letter of dedication and three times in Book 1 Chapter 9–10, but the entire introduction to Book I (which was deleted from the first published text in 1543) conveys that theological point. Whether the theological justifications contained in Rheticus' *Narratio Prima* were stimulated by Copernicus cannot be known; but they are consistent with his views.

derived from two sources: the classical philosophical tradition stemming from Plato and Aristotle and the Judeo-Christian tradition of the Bible.[13] From the latter (e.g., Psalm 19, Romans 1) came the central idea that the creation reflects its creator. From the former (especially from the Platonic-Pythagorean wing), Copernicus derived the belief that the real elements of the universe were geometrical qualities, best exemplified in the shapes and movements of celestial bodies. These were the "Forms" that were implanted and innate in the human mind so that they could be "recollected" and thus, *recognized* in the universe. Aristotle's views, to which Copernicus everywhere adheres (with certain important alterations) were not very dissimilar except that for Aristotle, of course, the Forms are incarnated *in* things and are thus *discovered* by transaction between the human organism and the environment. For Copernicus, as a Christian, this means that the true forms, having been created by God, are *revealed* in his creation. Since the "Best and Greatest Artist" and "Artificer of all things" has thus designed and created the universe and has created human beings in his own image, the *true* construction of the universe is intelligible to man and can be apprehended by mathematical reasoning. Knowledge of the universe is thus the result of divine disclosure: and it was the essence of Copernicus' religious tradition that one not only can but *should* study the creation to discover the true design of its creator:

> "... it is the loving duty [of the philosopher] to seek truth in all things, in so far as God has granted that to human reason."

These words from his letter of dedication clearly and simply state Copernicus' entire view of the aim of science. He states this aim again in his dedicatory letter where he describes his purpose as seeking to understand "... the movements of the world mechanism created for our sake by the Best and Most Orderly Workman of all." In this place, Copernicus directly ties this belief to his "annoyance" that "the philosophers, who in other respects had made a careful scrutiny of the least details of the world, had discovered no sure scheme for the movements of the mechanism ..." [14]

By themselves, such theological/aesthetic criteria will not decide

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[13] After all, "Metaphysics" was not the title Aristotle gave to the work; it acquired that title because it came right *after* his *Physics;* hence, "after-Physics". *He* called it "Wisdom" or „Theology" which, for him, was First Philosophy.

[14] The tradition of Natural Theology which these beliefs reflect came to be expressed in Western Christendom by the concept of nature as a "secondary revelation" of God and is also to be found in numerous references to the "Book of Nature" in the literature of the 16th century. The first explicit reference to this is in the writings of John Scotus Erigena in the 14th century though the concept goes back to Augustine.

the matter of scientific truth any more than will accuracy or observational agreement. But for Copernicus, no theory can be true that blatantly violates such principles. They function then for him as *necessary* but not sufficient conditions of truth. Thus, the absence of such qualities in Ptolemy falsified that theory for him and their presence in his theory served to increase his confidence in its truth. [15]

Copernicus now must argue for its plausibility by demonstrating that the assumption of the earth's motion not only unites the system but makes all its parts totally inter-dependent:

> "And so, having laid down the movements which I attribute to the earth ... I finally discovered by the help of long and numerous observations that if the movements of the other planets are correlated with the circular movement of the earth, and if the movements are computed in accordance with the revolution of each planet, not only do all their phenomena follow from that but also this correlation binds together so closely the order and magnitudes of all the planets and of their spheres and the heavens themselves that nothing can be shifted around in any part of them without disrupting the remaining parts and the universe as a whole."

So much has Copernicus accomplished within the domain of traditional mathematical astronomy, without requiring philosophical or theological adjustment. But that would leave it a mere hypothesis, and Copernicus would have the truth. While such arguments and demonstrations establish the plausibility of his theory and undoubtedly strengthened his conviction in its truth, his reasoning is insufficient to establish that it is true or even probable. To do that he must now argue as a philosopher and theologian: first, by refuting the traditional but powerful objections to terrestrial motion: second, by demonstrating the necessity of that motion to integrate celestial movements and to show that it is the only way to do so; third, to provide an alternative physical principle that will account for that motion, and fourth, to demonstrate the validity and necessity of that physical principle by showing its consistency with accepted metaphysical/theological axioms.

Copernicus could anticipate the powerful physical and theological objections that would be raised against his theory. Indeed, he candidly acknowledges the difficulty of his position by admitting the apparent "absurdity" of his theory on grounds of popular belief, common sense and tradition, the most daunting of which is the unanimous geocentric testimony of sacred scripture. Hence his appel to the Pope that his work be judged only by mathematicians and his expression of scorn for those ignorant of that art who will "shamelessly distort some passage in *Holy*

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[15] In this respect, is potentially superior to Ptolemy in that it explains the anomaly of retrograde motion, as well as the order and periodes of the planets.

Scripture ... to attack my work." [16] Though he disclaims fear of such criticism here, he expressed it privately to others and hesitated to publish his work for over thirty years until persuaded to do so by his friends. It is a tribute to the strength of his conviction and to his sense of obligation to share his discovery that he did venture into the risky domain of philosophical and theological argument. Copernicus proceeds to build probability by refuting the standard philosophical objections to a moving earth (Book I, Chapters 7-8), after which he concludes: "From all these considerations, it is more probable that the earth moves than that it remains at rest." Probability is gained however, not only by the refutation of objections but by the fact that in his system, all the phenomena physically follow from his assumption of motion. This leads to the inescapable conclusion that his system is not simply another possible hypothesis, but the *only* possible one:

> "And so we find an amazing symmetry with this mathematical system of the universe and a certain tying together of the harmony of movement and the size of the spheres *such as can be found in no other way.*" (Book I, Chapter 10, italics mine).

The problem now confronting Copernicus is this: if the earth indeed moves and no stellar parallax is observed nor other disconfirming physical consequences occur, what physical principle that is consistent with the uniformity of motion will account for that? So far, his only *physical* arguments have been falsifying ones; now it is necessary for Copernicus to provide an alternative principle of motion that will account for and necessitate terrestrial movement.

Here Copernicus turns once again to the ancients and draws from the Platonic-Pythagorean tradition a doctrine from which to derive such a principle of motion. In a major departure from Aristotle's physics, Copernicus asserts that motion is determined by geometrical form, not by substance. The entire argument in Book I of the *Revolutions* hangs on the argument from geometrical form and centers on the concept of sphericity. Chapter 1 maintains that the universe as a whole is spherical; chapters 2 and 3 affirm that the earth is spherical; chapter 4 contends that the motion of celestial bodies is uniform and circular. So much is traditional Aristotelian doctrine; but then comes his crucial physical argument:

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[16] That Copernicus is dissembling is shown by the fact that he expressed such fears in a letter to Andreas Osiander. This letter has vanished but we know of its contents from Kepler's citation of portions of Osiander's reply to Copernicus. If Kepler's report is accurate then Copernicus was not as confident as he sounded in his dedication. For that reason, I suspect, he tactfully but pointedly refrained from making any comment about biblical interpretation which could be used against him.

> We now know that the motion of the heavenly bodies is circular. *Rotation is natural to a sphere and by that very act is its form expressed.*" (Italics mine).

This physical principle provides Copernicus with the necessary basis for explaining the motion of the earth. By arguing that the spherical shape of a heavenly body is itself a sufficient condition for its rotation and from the fact that sphericity is exhibited by the earth, he has made terrestrial rotation *necessary*. By extension, since the earth is embedded in a spherical shell which, by virtue of *its* form, *must* rotate, the earth also revolves around the sun.

In this significant but qualified departure from Aristotle's *Physics*, Copernicus has in one stroke circumvented and negated Aristotle's elaborate effort in *De Caelo* to construct a system of homocentric movers and unrolling spheres by which to explain the transmission of motion. For Copernicus, it is no longer necessary to be concerned with the effective transmission of motion from mover to moved. By making the spherical form itself the sufficient determinant of motion, the mover has, so to speak, become internalized, inherent in a heavenly body as the power which causes them to rotate and to cohere.[17] Further, the sphere of the Prime Mover which, in Aristotle, imparts motion to the entire system can be dispensed with.

But at this point, a new problem arises; if everything in the universe is spherical in form and therefore, in circular rotation, what is now to be the "benchmark", the fixed reference point from which absolute or real motion can be determined? What, in short, will now determine the "place" of celestial objects now that the "Unmoved Mover" which heretofore had fulfilled that function, is eliminated? For if nothing rests in the system, no distinction between real and apparent motion is observationally or theoretically possible and Copernicus would be forced into a relativistic position, in contradiction to his repeated insistence upon consistency with "the rule of absolute motion."

For both philosophical and theological reasons, Copernicus cannot settle for a relativistic universe as did Cusa for the simple reason that his system must have *astronomical* as well as theological significance which Cusa's universe did not have. Copernicus will establish its theocentricity in another way as we shall shortly see. But for astronomical and theological reasons, the question of which motion is real and which merely apparent—that of the earth or that of the stellar

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[17] It should be noted that, in one sense, this *is* in accordance with Aristotle's basic distinction between celestial and terrestrial motion (in Book I, Charpter 8). It is by placing the earth itself among the planets that it acquires rotational motion while leaving the physics of the earth intact.

sphere—*must* be established if his theory is to be consistent and to command assent. Since his entire argument hangs on the assumption of the earth's motion, something else in the universe must be taken as immobile. And inasmuch as the diurnal motion formerly attributed to the sphere of the fixed stars is now accounted for by the moving earth, it must be the sphere of the fixed stars that is at rest. [18]

But what will justify this? How can the sphere of the fixed stars be immobile? Given his obsession for philosophical consistency and his own physical doctrine that "rotation is natural to a sphere," how can the sphere of the fixed stars *not move*? The presence of such a glaring inconsistency in one whose aim was the search for such consistency poses a genuine dilemma for Copernicus. And it is impossible for him to resolve it by demonstrating on physical or optical grounds whether it is the observer or the observed that is moving. So he must do so on metaphysical and theological grounds. That is, the physical inconsistency can only be warranted metaphysically by the theological function served by an immobile stellar sphere. [19] He hints at this theological justification when, at the close of his arguments against objections to terrestrial motion (Book I, Chapter 8) he appeals once more to the Platonic-Pythagorean tradition and to its doctrine of the *nobility* of immobile heavenly objects:

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[18] The clarity of Copernicus' assertions of the immobility of the stellar sphere and the sun, make it all the more surprising to read in O. Neugebauer's *The Transmission of Planetary Theories in Ancient and Medieval Astronomy,* New York, 1955, p. 27: "The question as to which body is 'at rest' is of course without any interest, particularly when no such physical body existed in the whole Copernican system."

[19] In Book I, Chapter 7, while refuting Ptolem's arguments against a moving earth, Copernicus attributes an argument to Ptolemy that if the earth rotated on its axis, it would have disintegrated long ago. In Book I, Chapter 8 he refutes this argument by reference to his doctrine that "rotation is natural to a sphere." The mystery here is that, as I can determine, Ptolemy never argued specifically against the diurnal rotation of earth nor ever wrote in terms that could even vaguely be construed as a concept of centrifugal force which Copernicus ascribes to him. It is true that he argued against "those" who advocated terrestrial motion on the grounds that such motion would "leave animals and other objects hanging in the air," and even that such motion would cause the earth to "fall out of the cosmos." But, and this fact seems to have escaped Copernicus, Ptolemy did not differentiate between diurnal rotation and annual revolution and did not argue that the earth would "dissipate" under diurnal rotation. To date, I have found no reference in contemporary literature calling attention to this curious mis-statement on the part of Copernicus. It could be that this was then a popular impression that Ptolemy had taught some concept of centrifugal force, considering the way Ptolemy was taught (usually at third-hand) in the universities. If that were so, Copernicus would naturally have felt the necessity of rebutting argument. It would have been advantageous for him to have cited Ptolem's precise words, however. This would have showed his opponents that even his greatest predecessor had not mentioned any possible "dissipation" of the earth, thus strengthening his own physical arguments.

> "Further, we conceive immobility to be nobler and more divine that change and instability, which latter is more appropriate to earth than to the universe. Would it not then seem rather absurd to ascribe motion to that which contains or locates and not rather to that which is contained and located, namely the earth?"

What lies behind this argument is a final, undisclosed metaphysical/theological assumption which he shares with Aristotle: namely, that everything in the universe has a *place*, including the universe as a whole. He writes:

> "Given the above view—there is none more reasonable—that the periodic times are proportional to the sizes of the orbits, then the order of the spheres, beginning from the most distant is as follows: Most distant of all is the Sphere of the Fixed Stars, containing itself and everything, and being therefore itself unmovable. It is the place of the universe ..." (Book I, Chapter 10).

This doctrine comes from Aristotle who had defined "Place" (*topos*) as "the innermost motionless boundary of what contains." [20] That "place" was, of course, the Prime Mover in Aristotle's system; it was defined by him as without "place," being uncontained by any further receptacle. Yet, if it moves, as it surely must in order to impart motion to the contained, then according to Aristotle's definition, it changes its "place," which means it had "place" to begin with, which would lead Aristotle into a blatant contradiction. As is well known, Aristotle avoided this contradiction by positing the Prime Mover as an *unmoved* Mover, justifying it on metaphysical grounds and explaining it as a teleological rather than an efficient mover. Copernicus follows a similar procedure: however, he has dispensed with the Prime Mover by his sphericity principle of motion and, in so doing, has lost the very thing that determines "place." And without that, he has lost the possibility of determining absolute motion. Either Aristotle's definition of "place" had to be altered or his doctrine of the motion of the outermost sphere had to be rejected. Copernicus resolved this by rejecting the motion of the outermost sphere which, in his system, is occupied by the stellar sphere. This sphere, accordingly, becomes the "place of the universe." [21]

Dispensing with Aristotle's concept of the Unmoved Mover means that Copernicus has also dispensed with Aristotle's concept of God, as

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[20] Aristotle, Physics, IV, 4 (212a, 20–21), transl. by P. H. Wickstead and F. M. Cornford, Loeb Classical Library, 1929, Vol. I.

[21] His *Letter against Werner* (1524) contains his early arguments against the motion of the eight sphere. It is not often noticed that, inasmuch as it was also Aristotle's belief that immobility is more noble and divine, the fact that the earth as a whole is immobile in his system represents a serious inconsistency which Copernicus must have been pleased to eliminate!

he must do to be consistent with his own Christian theology. This means that the concept of "place" has acquired not only a different physical identity but has also gained a different theological meaning, a meaning acquired from the biblical tradition. In that tradition, the key phrase, "place of the universe" had come to be used as a synonym for God as the result of nearly two millenia of Jewish and Christian speculation on the name of God. [22]

Because the covenant name God gave to Israel—YHWH—was ineffable and not to be misused (by injection of the second commandment of the Decalogue), late Judaism came to avoid direct references to God and developed several substitute terms of address (*elohim*, *Adonai*) and other terms of reference by which to distinquish between God, Himself, who is beyond all perception, and His visible self-manifestations. The term, *Shekhina* 'Glory' was one such "name", commonly used to refer to a visible manifestation of God,ofte n described in appearance as a radiant cloud or light. Another "name" was "heaven" and still another with similar cosmological connotations was "place" (*Māqōm*). [23]

In the literature of 1st-century Palestinian Judaism, this practice had led to considerable cosmological/theological speculation in which God was endowed with both personal and spacial attributes. The connotations of "place" to which this led and which entered deeply into the Christian tradition can be seen is such statements in the Mishnah as: "Why do we call the Lord, 'Māqōm'? Because the Lord is the Dwelling Place of the world, but the world is not His dwelling place."

During the Middle Ages such ideas were developed much further in

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[22] In the Christian tradition, God is pre-emminently the *creator* of the universe, a concept entirely absent in Aristotle. For him, matter was co-eternal with the Unmoved Mover and was thus uncreated. Moreover, the biblical conception of God is everywhere of a God who *acts* in continual creative and redemptive. Aristotle's God had not motion. As Prime Mover, God was defined as pure Actuality and therefore, unmoved. As Aristotle argued in his *Methaphysics*, the Prime Mover moves others by being their final cause, that is, by simply being the object of their love and desire. As a Christian, Copernicus had to modify theology of Aristotle's system to be consistent with biblical conceptions of God. In this, he is following Thomas Aquinas, whose first argument for the existence of God is a carbon copy of Aristotle's *Physics*, Book 8 and the *Metaphysics*, Books Lambda and Beta. Their respective concepts of deity thus share some functions; for both, deity defines "place" by providing a final cause and limit to account for change and motion. Thus, for both Aristotle and Copernicus, God is the First Principle of Being and Becoming and thereby establishes the rationality of the universe which makes knowledge possible.

[23] Examples may be found in Dt. 33:27; "... the place where I cause my Name to dwell"; Psalm 90:1: "Lord, you have been our dwelling place..." (cf. Ps. 132:5,7). In the Targums (Aramaic paraphrases of the Bible), the targum of Exodus 25:8 (which reads: "Let them make me a sanctuary that I may dwell among them") is rendered by: "... that I may let my Shekhina dwell among them." For a further development of these themes, see M. Jammer, *Concepts of Space*, New York, 1960.

Jewish mystical speculation represented by the Caballa, which became widely studied during the Renaissance and syncretized with the Platonic-Pythagorean tradition and its doctrines spread by such thinkers as Mirandola, Agrippa, Reuchlin, Fludd, Campanella, Bruno and others. It is possible and highly likely that Copernicus encountered such ideas during his years of study in Italy and that they gave him an important insight into the way he could make his cosmological system firmly consistent with Christian theology. By identifying the outermost stellar sphere as the "place of the universe," he is, like Aristotle, endowing that sphere with theological as well as physical significance, making that sphere which is closest to the Abode of God (the Empyrean) serve as the ultimate determinant of all change and motion in the universe. Thus, while the immobility of that sphere is inconsistent with the physical principle of sphericity, it is *theologically* consistent with the religious axioms of Copernicus' system and with Christian doctrine itself, which then was the final arbitrator of truth and the ultimate legitimator of any system of thought. The religious rationale Copernicus gives for his scientific efforts in the letter of dedication to the Pope and in his introduction to Book I of the *Revolutions* plainly reflects these discreet, but significant, theological justifications.

That this contention is correct is supported, moreover, by an additional fact: Copernicus has one other spherical body in his universe that is likewise immobile—the sun.[24] While the sun does not for Copernicus fulfill any discernable astronomical or physical functions (as it is later to do for Kepler), it does perform a similar theological function like that of its cosmological counterpart, the stellar sphere; it stands at the center of Copernicus' system as a visible symbol of God's presence in and his sovereignty over the entire universe. As such, and because of its long and rich association with God in the Judeo-Christian tradition, it provides an appropriate symbol for a *theocentric* universe.[25] Copernicus saw that arrangement not merely as mathematically useful or physically necessary but *providential*:

> "In the center of all the celestial bodies rests the sun. For who in this most beautiful temple could place this lamp in another or better place than that from which it can illuminate everything at the same time? Indeed, it is not unsuitable that some have called it the light of the world; others, its

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[24] Clear statements of the immobility of the sun can be found in Book I, Chapter 10 of the *Revolutions*; "I also say that the sun remains forever immobile...," and later, "In the center of all rests the sun."

[25] The associations of the sun and light with deity in the biblical tradition are numerous, beginning with the first creation account in Genesis 1 where the first thing to be created is light, signifying the visible manifestation of God, who was present before the ordering of the began.

> mind, and still others, its ruler. Trismegistus calls it the visible God; Sophocles' Electra, the all-seeing. So indeed, as if sitting on a royal throne, the Sun rules the family of the stars which surround it."

For Copernicus, as later for Kepler, there is a marvelous cosmic correlation between the physical universe and God.[26] What else but such a religious vision could have evoked that ecstatic outburst of praise contained in the last line of Book I, Chapter 10: "How exceedingly fine is the divine work of the Best and Greatest Artist!"

In such fashion did Copernicus disclose his motivations and the manner in which formulated, reasoned, and justified his novel theory. I have attempted to demonstrate thereby the importance of the entire process of "discovery" to our understanding of science and to elaborate the previously noted but oft-neglected role of Copernicus' theology in the process of that discovery.[27] In the course of his argumentation, a definite pattern of reasoning emerges which renders such epitaphs for discovery as "irrational" and "subjective" patently inappropriate. One may not like Copernicus' reasons for coming to believe in and justifying his system but that is not a rational ground for refusing to accept them as *reasons*. We must therefore remind ourselves that scientific investigation had much broader implications for Copernicus than it has for many today and included those purposes which we classify as religious and extra-scientific. Such considerations, however, were crucial for Copernicus and were demonstrably instrumental for his achievement. By his own statements they were the primary motivation for his research, the ultimate source of the truth he discovered, the basis of his confidence in his conception as true, and the final justification for believing in, asserting, publicizing and commending that theory to others. In the absence of any available or then-conceivable confirming evidence, it was only on such grounds that belief and persuasion were possible. And without that belief, there would have been no *Revolutions* and

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[26] G. Holtan has documented in his study of Kepler that what was implicit in Copernicus becomes explicit in Kepler, for whom the sun fulfills three functions: as mathematical reference point, as physical mover and as theological center. (*Johannes Kepler's Universe: Its Physics and Metaphysics*, in: *Toward Modern Science*, R. M. Palter (ed.), New York, 1961, Vol. II).

[27] Among the few who have noted that the basis of Copernicus' confidence is primarily theological are: E. A. Burtt, *The Metaphysical Foundations of Modern Science*, New York, 1952, Ch. II; A. O. Lovejoy, *The Great Chain Being*, New York, 1960, p. 111; W. Heisenberg, *Tradition is Science*, in: *The Nature of Scientific Discovery*, O. Gingrich (ed.), Washington D. C., 1975; C. F. von Weizsacker, *Die Einheit der Natur*, Munich, 1971.

One could go further and argue for the importance of meditation to Copernicus, a word Copernicus twice uses in his letter of dedication. On its significance for Copernicus, see K. Górski, *Mikołaj Kopernik, Środowisko społeczne i samotność*, Warsaw, 1973. An English précis will soon be published under the title, *The Social Background of Copernicus and His Solitude*.

perhaps, no revolution in science, since the same considerations that led Copernicus to belief were those which made his theory *believeable* to his earliest adherents, especially Kepler. Indeed, these criteria were not idiosyncratic or unique to Copernicus and therefore, "subjective;" rather, they were, to use Herbert Feigl's illuminating term, "inter-subjective," the "shared basis of values" among scientists by which claims to truth have always been tested.[28] In that light, the wisdom of I. Bernhard Cohen's statement becomes apparent: the "logic of discovery" converges on the "logic of the discovered."[29]

Finally, we should remind ourselves of one other fact: the chief purpose of science is to discover new things, not merely to test the products of discovery. To ignore the process by which discoveries have been made is to debilitate science education, and to conceal, rather than reveal, what makes science such a fascinating and a truly creative human enterprise.

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[28] T. Kuhn, whose earliest writings were about the phenomenon of discovery has had something helpful to say about that in his *Objectivity, Value Judgement and Theory Choice,* in: *The Essential Tension,* Chicago, 1977.

[29] I. B. Cohen, *Franklin and Newton,* "The American Phil. Soc.", Philadelphia, XXVI (1956), 657, p. 190.