Dialectic and Rhetoric: Questions and Answers in the Copernican Revolution

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ABSTRACT: The interplay between dialectic and rhetoric is an increasingly prominent characteristic of scientific discourse during the Copernican Revolution. Both of these forms are related means of inquiry, sharing the same basic agonistic structure. Although similar in their concern to find answers to difficult questions, in the scholastic view these two differed widely in stylistic expression, purpose, and area of application. In this paper, I illustrate the prevalence of the question-answer format in classroom teaching on astronomy and show that it dominates some of the most important writings on the Copernican thesis during the late sixteenth and early seventeenth centuries.

The essay first explicates the nature of dialectic and rhetoric as taught by Ludovico Carbone, a master pedagogue of the period. It then compares the use of both in Copernicus's *De revolutionibus*, some writings of Kepler, and Galileo.

KEY WORDS: Demonstration, dialectic, hypothesis, rhetoric, *topoi*.

An erotetic logic of question and answer based on informed opinion underlies most of scientific arguments advanced in the debate over the Copernican thesis in the late sixteenth and early seventeenth-centuries. The expression in discourse of this form of thinking still bears the marks of the acme of its development during the Middle Ages: the academic investigative method known as the scholastic disputation. The disputation was the natural outgrowth of dialectical inquiry treated by Aristotle in the *Organon*, further developed by the scholastic masters of the emerging universities and applied by them to problems of continuing concern in natural philosophy and theology. Although the format in which the investigations were presented might change during the Renaissance, the writings of the controversialists were conceived within that dialectical framework, whether issuing as treatise, letter, or dialogue. Sometimes these writings were specifically labeled disputations. In the hands of a master of language like Galileo, the questions were framed and answered in a classically styled dialogue, returning the dialectical pursuit of truth to its roots in Socrates. When astronomical observations provided some evidence for the Copernican theory and certain proof seemed within his grasp, however, Galileo turned also to rhetoric in a last-ditch attempt to persuade his audience to accept the theory. For that matter Copernicus too had found rhetorical argument useful, but in a different way: he employed it to prepare his patron and readers for his revolutionary thesis.

In this period, then, in a departure from conventional practice scholars began to supplement dialectic with rhetoric in advancing scientific claims.[1] Sometimes answers to scientific questions were characterized by rhetorical appeals and sometimes the nature of the questions shifted from those solely concerned with science to those in which the practice of science became enmeshed with politics.

The introduction of rhetoric into scientific discourse was a significant change because most scholars in the sixteenth-century expected scientific investigations to be governed by Aristotelian canons and so to be restricted to the techniques leading to necessary demonstration: induction, deduction, and dialectical inquiry. When causes of phenonomena were not readily apparent and a necessary demonstration of these could not be made, dialectical inquiry was the approved manner of exploring alternative explanations. Rhetoric's domain was then restricted to matters of public concern where certainty was deemed unattainable and audience's interests and emotions played an important part.

In this essay I am concerned mainly to illustrate the prevalence of the dialectical question-answer format in classroom teaching on astronomy and in some of the most important writings on the Copernican thesis during the late sixteenth and early seventeenth century. In passing I will note the manner in which rhetoric was employed in these writings. To shed light on the formation of concepts of dialectical and rhetorical argument in the period, I shall turn to two works of a master pedagogue of the time, Ludovico Carbone. His teachings preserve the approach used by his former teachers, the Jesuits of the Collegio Romano, who were renowned for their erudition in natural philosophy, mathematics, and theology as well as for their reforms of education.

CARBONE ON DIALECTICAL ARGUMENT

Carbone was a little-known figure until recently when my colleague William A. Wallace discovered that this sixteenth-century scholar's *Additamenta ad commentaria doctoris Francisci Toleti in logicam Aristotelis*, published in 1597, was strikingly similar to an unpublished notebook of Galileo, MS 27, containing a commentary on Aristotle's logical questions. The source of both of these works, Wallace has shown, were lectures given on the *Posterior Analytics* at the Jesuit College at Rome, The Collegio Romano.[2] Corroborating the physical evidence provided by a textual comparison of these writings is the testimony of Paulus Vallius. Vallius declares in his own published work on the subject, *Logica* (1622), that more than twenty years earlier his lectures at the Collegio, and some also of other professors there, were appropriated and published by a man whom he does not name, but, who, from his description, could be none other than Carbone. Wallace reveals that these same lecture notes on Aristotle's logic were copied by Galileo into a notebook, which though unpublished, still exists in manuscript form. Galileo did so, most probably, to gain a better knowledge of logical methodology. The Jesuits' reputation in mathematics and logic had prompted him to consult with them on questions of mathematics during this early period of his life.

Carbone, who was a theologian and a professor at the University of Perugia, was educated at the Collegio. In light of the subsequent discoveries noted above, it is interesting that he expressed his admiration for his Jesuit professors in a preface to one of his six published books on rhetoric. As I have related elsewhere, he praises the content of their lectures and their methods of instruction, and he probably thought of his publications as a testimonial to their teachings.[3] He must have regarded of his own contribution as one of polishing, reframing, and dilating the more formal and denser presentations of his teachers.

I will briefly summarize some of the material from a work closely related to the *Additamenta*, Carbone's *Introductio in logicam* (1597), which was also derived from Vallius's lectures at the Collegio. It offers an exceptionally clear discussion of the nature of scientific argument as it was practiced in the period.[4]

Carbone outlines the structure of dialectical reasoning in this way. He first explains that the dialectical syllogism is composed of probable propositions whose premises are held to be worthy of acceptance and thought to be true. Acceptability is attained in various ways. Some premises, he says, are admitted by all, others by well informed people, and others by experts in a field. (Of the last, some probable opinions granted by experts are not accepted by all, and therefore these are not numbered among the probables, i.e., Plato's view that the universe had a beginning.) Propositions that are deduced from other probables are another class of those statements accepted as probable. A syllogism composed of probable propositions, then, or one that also may include a necessary proposition, is said to be dialectical. Carbone remarks that this form is sometimes called an *epichirema* or an *aggressio* because it is well suited to attacking an opponent (p. 171). He explains that the purpose of the probable syllogism is to explicate probable questions, also referred to as problems or theorems.

The difference between a dialectical proposition and a dialectical question is taken up next. As he notes, the proposition is the opinion or assumption held by the reasoner. When it is challenged as in the following: "Is it true that one ought to seek after riches?", it then becomes a question. Carbone clarifies the point:

> A dialectical proposition, then, is a probable interrogation that questions something regarded as true by all people or at least by the majority. A dialectical question, on the other hand, is a problem about which all or many people take neither side, or common people take a position opposite to the educated or the educated opposite to the majority, or even differ on it among themselves. (p. 171)

The use of the *topoi* or topics in finding answers to dialectical questions, a procedure explained in Aristotle's *Topics*, is the next relevant concern for Carbone. When posing a question the reasoner is actually asking whether a particular predicate can be applied to the subject. To explicate this, Aristotle observes that there are four major types of queries that can be made: questions of definition, property, genus, or accident. All others are reducible to these. One may ask these questions implicitly or explicitly; for example, one may ask, "Is justice the genus of virtue?" Or one may simply examine whether justice is a virtue.

Carbone explains that the *topoi* have been developed from these four questions to assist one in finding middle terms for the dialectical syllogism. In the syllogism's most scientific form, necessary demonstration, the middle term is joined "necessarily" to the other terms on the basis of a causal connection that permits an inference to be drawn with certitude. In its dialectical form the syllogism cannot attain this rigor. Its middles are "something probable, invented to induce belief" and it is "conjoined verisimilarly, either to both extremes of a question or with one or the other, so as to gain an assent to what is proved, though without absolute necessity." (p. 172)

The topics in Carbone's view serve a critical function in the development of dialectical arguments. His rationale for treating them at length is worth quoting:

> Since human teaching makes use of opinion no less than it does of science, and since many more things are held by opinion than are held by science, those who wish to be concerned with the knowledge of things should be well informed about topical "places" or probable arguments. For this reason we intend . . . to treat it a bit more fully, though not to the full extent that is certainly possible. . . . In my judgment, however, nothing is more suitable for an educated man than to be prepared with the benefit of this doctrine to argue knowledgeably and persuade subtly on either side of a proposed topic, as we have taught more fully elsewhere. (p. 172)

The work referred to probably is his *De Oratoria, et Dialectica Inventione* (1589).[3] In this more "abbreviated" discussion of his logic text Carbone still devotes thirteen chapters to explicating the topics.

Before we leave Carbone's *Introductio*, whose original source may have played an important part in the formation of Galileo's remarkable argumentative skills, we should take note of its author's closing "animadversions on the topics." Thirteen in number, these might more accurately have been termed "rules" for exploratory argumentation. The third, sixth and seventh are especially interesting for an understanding of the way in which these techniques of invention are related to argument and to one's special knowledge of the sciences. The third rule provides a summary of the topics and their purpose:

> When something is proposed to be proved, we should examine the subject and the attribute of the question and for each we should look into the term, the definition, the denomination, the parts, the causes, the effects, the antecedents, the consequents, the adjuncts, the similars, the dissimilars, and the repugnants; from these, various arguments can be drawn, and these will offer us a vast supply for disputation. (p. 206)

Rule six notes the relation of the common to the proper or special topics:

> Since topical places do not contain subjects themselves but are only notes that indicate where matters are hidden, therefore, when there is a paucity of subject matter the doctrine of proper topics should be refilled; those who do not attend to this will learn dialectics in vain. The person wherefore who wishes to become a perfect dialectician, that is, an artist who is able to discourse with probability on any matter proposed, should prepare himself by hearing, reading, and writing out teaching relating to the proper topics. (p. 207)

The proper topics are then clarified in the seventh rule:

> In acquiring knowledge of proper topics one should go to the special arts or to the subjects that are treated in the special arts, and in this way one will be able to prepare from them topics for oneself. First one should learn the proper meanings of ambiguous words and the terminology of that art; then one should perceive the first principles on which the entire discipline depends. After that one should learn the subject matter in a general way, the several parts, causes, and properties; following that one should descend to particulars. One should do this in physics, metaphysics, and ethics, and in other arts, and in all of learning. Thus only the person who has filled his mind with the doctrine of common and proper topics can be called a true dialectician. (p. 207)

In this very important admonition Carbone defines the province of the special topics, topics of which anyone who argued questions relating to a particular science had to be aware. One notices here that he has supplemented Jesuit teaching on dialectic with Aristotle's treatment of the use of the *topoi idioi* in the *Rhetoric*. These are specific to a subject and can only be acquired through knowledge of that subject, he explains. Aristotle also notes that when one enters deeply into a particular subject one leaves the area of rhetoric or dialectics.[5]

Carbone's treatment of dialectics is, no doubt, representative of the scholastic concepts of logic in the universities of his day. He bases much of his discussion on Boethius's *De topiciis differentiis*, a work then commonly studied. Granted that his explication is probably clearer and fuller than the treatment many of his contemporaries might have provided, there is clear evidence of such instruction having taken root. This, as we shall see, can be discerned even in the writings of the scientists of the period.

PRE-COPERNICAN ASTRONOMY

The scholastic view that dialectical reasoning is applicable to any subject and plays a special role in the development of science was generally accepted in all of the universities before the beginning of the modern period. And dialectical logic continued to be taught and seriously regarded in the universities into the nineteenth century, long after its methodology ceased to delight students weary of the tedious pedagogy to which many of them were subjected. Rhetorical reasoning, wherein appeals from emotion and from the authority of the speaker worked in concert with logical proofs, was never explicitly accepted as applicable to scientific matters. Yet it was to assume an important role in the developing Scientific Revolution.

On the eve of that revolution textbook expositions of the subject of astronomy in the schools were largely couched in an erotectic format. The treatises that are extant generally read like the disputation the neophyte was expected eventually to offer successfully before a degree could be conferred on him. We tend to forget that disputations given by a distinguished scholar were preferred entertainment during the late Middle Ages and that such displays continued to be accorded star billing on special occasions during the Renaissance.

Besides the later work by Ptolemy, the *Almagest*, the text most relevant to the cosmological issues contained in the Copernican debate was Aristotle's *De caelo, On the Heavens.* Its conclusions were to provide the principal coordinates of the cosmology of the pre-Copernican world. In a valuable analysis of this text, Benedict M. Ashley points out that although Aristotle departed here from his usual method of inquiry, which is to proceed from observation of the better known (the process followed in dialectics) to knowledge of the lesser known, he did so simply to leap over the gap that would prevent him from investigating what is lesser known. As Ashley notes, "The fact that he [Aristotle] undertook it [the general consideration of the universe] as the first problem of special physical science does not mean that he abandoned his determination to proceed always from what is better known."[6] The text sets forth the problems concerning the cosmos that Aristotle felt impelled to solve. In the first book he treats the general nature and motion of bodies in the universe; in the second, the nature and motion of the heavenly bodies; and in the remaining two, problems related to the composition of matter, the elements, as these come into being and pass away.[7] The last two books are often separated from the first by the commentators and entitled *De mundo* or *De elementis.*

Since the whole of Aristotle's effort is conceived of problematically, the texts that build upon this foundation also adopt the question-answer format. The answers given by Aristotle are arrived at in a number of ways.

He reasons both dialectically and demonstratively and offers both physical and mathematical proofs. The scholastics followed in his footsteps but they further applied the dialectical methodology outlines in the *Organon* to raise additional questions or to controvert parts of his conclusions.

Before we take up the debate over the Copernican thesis, it would be well to look at the type of commentary on Aristotle's *De caelo* that would be known to the participants. Since the texts of Aristotle are so dense and even fragmentary at times, Renaissance scholars depended upon the rich commentarial tradition that by this time issued from Greek, Arabic, and Latin sources. Here, the work of Carbone can provide one of our examples, and another may be drawn from a second notebook of Galileo, MS 46, which includes a commentary on Aristotle's *De caelo*.[8] Both derive from Jesuit lectures at the Collegio Romano as in the case of the logic notes. Carbone probably expected to publish his manuscript since it contains a title page and a preface. I came across the work unexpectedly while searching for Carbone's writings on rhetoric in the rare book room at the Biblioteca Nazionale Centrale in Florence. (He published six treatises on rhetoric, five on theology, two on logic, and one on philosophy.) A brief comparison of Carbone' manuscript with Galileo's can illustrate well the transition from the erotectic form behind the disputation to the more expository style of scholarly works in the Renaissance. Yet under the latter, the skeleton of the disputation is still apparent.

Surprisingly it is Galileo's version that is closer to the scholastic question-answer format of the disputation and Carbone's that is more discursive. The reason probably is that Galileo was a young man seeking to learn from the lecture notes he had obtained and so stayed close to his exemplar. Carbone, as a professor of theology, was anxious to polish the exemplar and present the material in a form relevant to the needs of his students and prospective readers.

Both works treat the same material and follow the order of Aristotle's treatise. In addition to a prologue describing the subject matter of *De caelo* and its relation to other works of Aristotle, this part of the work contains two treatises: the first on the universe, contains nine chapters; the second, on the heavens is composed of thirteen chapters. The second part, the commentary on *De generatione*, is concerned with the elements. It, too, is composed of two treatises: one on alteration, the other on the nature of the elements. The differences between the two manuscript commentaries are apparent from the outset, but the similarities in their coverage of the content is also notable. Galileo's text casts the subject of the first chapter as follows: "First Question. What is Aristotle's Subject Matter in his Books *De Caelo*?" In Carbone this is rendered as "On the object of these books." The point at issue is whether Aristotle intended to consider all of the universe in this work or whether he meant to limit his discussion here to the celestial regions. Much space was spent in commentaries in debating what Aristotle had in mind in treating something and in interpreting the meaning of his text.

While treating the components of the issue in different order, both show the same concern for providing doxographical evidence, or, as it is termed in the art of rhetoric, testimony from authority, to support the alternative views they rehearse and the conclusions they finally draw.

Galileo's notes first take up views of the important commentators over the centuries, those of Alexander of Aphrodisias, Simplicius, Averroes, and St. Thomas, which he ultimately shows to have been misconceived. He follows these with a statement of the correct view: "But I say first: the universe is not the subject of these books." (p. 26) In support of this proposition he offers four conclusions and follows these with five objections. Each of these objections is refuted in turn.

The methodology is that of the disputation, and, typically, it first considers what the subject is not and then defines it. After this, arguments advanced against the defining proposition are raised and refuted.

Carbone's treatment is more succinct and at the same time freer. He begins with a summation of the whole, "There are various opinions pertaining to their [the books] object, which we will set forth in the following conclusions." He presents each conclusion, prefacing many with what he declares at once are erroneous opinions. He mentions most of the same authorities as Galileo but provides an overview for his students, announcing in advance the direction of his argument. His treatment is not as repetitious and he passes over some distinctions.

Since the aim of the compositors of both manuscripts is different, as we have noted, the content varies somewhat also. Carbone expands the physical issues with a discussion of their theological implications. For example, in discussing the nature of the universe in the first book, Carbone offers a more general treatment than does the Galileo manuscript, concluding his consideration of the origin of the universe in the second chapter, thus,

> As some have said, it was made from chaos as from its first matter, as some ancient philosophers and poets have held; but in truth, as the true and Christian philosophy teaches, it was made from no preexisting material whatever; whence Paul, in his second [letter] to the Hebrews: we know by faith that the ages were formed by the order of God. (12r)

The chapters that follow, treating of the unity and perfection of the universe, continue in a different order, although both texts cover the same ground. Some of the issues exposed will become battle grounds in the years that follow. But at this time when Copernicus's thesis has not yet become a subject of debate, the texts review points of controversy on which most of their contemporaries were agreed.

Galileo's text on this problem contains six questions with replies to each, raising many distinctions and positing a number of conclusions. He begins his discussion by stating that there is "only one universe," and he provides three proofs from authority, opinions drawn from Plato, Albert the Great, St. Thomas, and Aristotle. In the last, he notes that Aristotle's opinion rests on the unity of order in existing things that extends from the unity of the first mover governing them, reasoning *a priori* and *a posteriori*, from the observation of existing order. Galileo points out the error of Democritus in holding a plurality of worlds, refuting that view by challenging the major premise that the origin of the universe lies in the chance aggregation of atoms. He continues his discussion, looking to the *topos* of final cause for sufficient deductive proof: "the world was created to this end, that our minds might come to the knowledge of God; but one universe is sufficient for acquiring this knowledge of God; therefore . . ." The syllogistic conclusion is not completed since it is so obvious. (p. 43)

In examining the question of the perfection of the universe, Galileo rehearses theological questions much discussed in the Middle Ages: God's ordinary and infinite power, whether God could make a more perfect universe, whether God is more perfect with the universe or without it, and whether the universe is perfect absolutely or in a qualified way. Each of these is answered with detailed conclusions and qualifications where needed, based on numerous authorities who reason mainly from the *topos* of property.

That Carbone is even more concerned with the theological implications than the philosophical arguments regarding astronomy is evident in his discussion. In discussing the unity of the world, Carbone is careful to separate the philosophical from the theological reasons and notes the different types of reasoning employed in the two conclusions that can be offered to the question. He says, "Philosophically speaking, the unity of the world can be construed only with probability." On the other hand, "theological speaking" to believe there is more than one world "is either a heresy or erroneous." (p. 17) In his exposition of the controversial opinions, he states clearly the substance of the issues he will treat and offers simple definitions and clear dialectical arguments. The authorities he cites range through Augustine, the book of Wisdom, to Dionysius.

The more humanistic style of his treatment is well illustrated by the following excerpt from chapter four on the perfection of the world:

> The universe is perfect in its kind. Proof, first: the world was made by the supreme Artist; therefore it is perfect. The deduction is valid, from the attributes of the cause to the attributes of the effect. Here pertains that most elegant hymn of Boethius in Carmine 3 of *De consolatione*, meter 9:
>
> All things thou bringest forth from Thy high archetype: Thou, height of beauty, in Thy mind the beauteous world Dost bear, and in that ideal likeness shaping it, Dost order perfect parts a perfect whole to frame. (14^{rv})[9]

The next treatise of Aristotle, On the Heavens, concerns matters of theoretical astronomy that are given much more space by Galileo, but both agree in their conclusions. In entertaining the question of whether the heavens are composed of the four elements, they both respond in the negative, arguing from the nature of the heavens and their attributes. Since the heavens do not change, reside in a superior position, are the largest entity, and move with circular motion, they cannot be composed of the four elements. The question of the number of the heavens is decided by the number of the motions of the planets: there are ten observable motions, so ten heavens. Objections to the conclusions are met with counterarguments from Aristotle and his commentators, and so resolved. The conclusions that both compositors make are generally based on deductive logic, in turn premised upon observation, which was then possible only with the naked eye. Carbone is concerned to prevent the development of heretical opinions and so in some instances carries the argument to areas not covered in Galileo's text, whereas Galileo expands the consideration of the physical questions.

The theology professor is careful to preserve the essence of the arguments, but he frames these with a general statement of the context, i.e., the debates of the earlier scholastics, and lists the conclusions that can be drawn in a succinct manner. The resolution of the questions is derived from reigning theological opinions or from the Church Councils. For example, in treating of whether the heavens are controlled by a world soul, Carbone says that the view "if not a heresy, is at least erroneous." He notes Irenaeus, St Jerome, and the Condemnations of 1277. (33^{rv})

Surprisingly, even though these manuscripts were composed forty years after the publication of *De revolutionibus*, little note is made of the work. Only Galileo records Copernicus's view that the sun is in the center of the universe, and he refutes it as being "opposed to the common teaching of philosophers and astronomers, and to reasoning establishing that the earth is in the center of the universe." He offers five arguments against it, mainly drawn from Ptolemy, Aristotle, and the *Sphere* of Sacrobosco. (pp. 71–74)

In the treatises discussed here preceding the Copernican debate, most of the texts record dialectical arguments, Carbone's more discursively expressed. In a few places necessary demonstrations are offered, and these follow the rules of Aristotelian logic for arriving at a conclusion from premises based on a knowledge of causes. In the debate that followed the publication of *De revolutionibus* the arguments advanced were generally mathematical demonstrations and dialectical arguments about the physical phenomena observed and recorded through the ages.[10] In 1610, when Galileo published the results of his observations with the telescope, more evidence could be offered to support Copernicus's contention. But here, too, dialectical arguments were really all that could be posited, along with some partial demonstrations from the effects noted. Obviously we may expect differences in the style of presentation and in language when aims and audiences shift.

ARGUMENTATION IN THE COPERNICAN DEBATE

The publication of Copernicus's great work in 1543 was an occasion for the introduction of rhetoric into the domain of science, both explicitly and implicitly. Copernicus provides a dedicatory letter to his *De revolutionibus*, addressed to Pope Paul III, containing rhetorical appeals that the astronomer hoped would help prepare the way for acceptance of the thesis of the work, which he feared would be rejected.[11] He, of course, did not anticipate the undoing of his thesis by the Lutheran theologian Andreas Osiander, who composed a foreword to *De revolutionibus* that was printed in it. It is not clear whether Copernicus even knew of Osiander's interpolation, for the book was not published until shortly before his death, and a copy was shown to him only on his deathbed.

Since the foreward was printed without indication of authorship, it was attributed to Copernicus. In it the author maintains that the book is only an "hypothesis" and as such not meant to be an affront to scholars, who would find their disciplines "thrown into confusion" if it were maintained as a thesis. In addition, the publisher added an advertisement on the title page that underscores the point that the book contains only a mathematician's "hypothesis," and notes that the work also includes useful tables that should serve to predict the movements of the planets. The advertisement ends with the motto of Plato's Academy, "Let no one untrained in geometry enter here." By privileging the knowledge contained in the book, the publisher probably hoped to render it innocuous to philosophers and theologians. It was the received view at the time that mathematical arguments, although achieving perfect proofs, would not be offered as necessary demonstrations of phenomena in the real world. The mention of the new astronomical tables might be expected to boost the sales of the book, since more accurate predictions were desired by both church and state authorities.

Copernicus, at the beginning of his letter to the Pope, admits the revolutionary character of the book. To soften the effect he provides a lengthy *narratio* wherein he defends his thesis against other views. The passage contains a kind of minidisputation. He points out the inadequacy of other theories and criticizes their proponents because they cannot agree about their computations nor the method used to arrive at them. Some propose eccentrics and epicycles to calculate the phenomena, but cannot show how these agree with the first principles of motion. They cannot even come to a consensus about the length of the year.

In order to protect himself from charges of innovating and thus failing to respect the authority of the ancients, Copernicus relates how he surveyed all known opinions for better ideas than those currently proposed. He found that indeed some authors had suggested an alternative explanation for the movement of the heavenly bodies that on reflection seemed to him to be much better. Cicero, Plutarch, and Philolaus, a Pythagorean, along with Heraclides and Ecphantus all suggested that the earth and moon revolve around the sun. This hypothesis permits the observed motions of the planets to fit together into a unified whole.

Copernicus then describes the organization of the book, patterning it closely upon the *Almagest* of Ptolemy, which he thought his work would replace. He appeals to "acute and learned astronomers" to study his treatise and see that his thesis must be right. Commending his work to the protection of the Pope because of the prelate's authority and appreciation for literature and astronomy, he voices the hope that His Holiness will "easily suppress caluminious attacks, although as the proverb has it, there is no remedy for a backbite." (5.34—36.)

Aside from the *petitio* of the letter, a normal part of the traditional letter format, Copernicus avails himself infrequently of rhetoric's aid in his book. The introduction is one of those places where rhetoric is employed, just as it had been by Ptolemy. The study of astronomy earns an encomium here from both astronomers. Ptolemy notes that it leads to the moral and spiritual edification of its students and Copernicus does the same.[12] Readers who revered the work of the earlier scholar would be comforted to find a parallel in *De revolutionibus*.

Copernicus, showing the breadth of his humanistic education, avails himself of rhetorical *topoi* in composing his epideictic excursus. He defines the discipline, reviews the etymology of related terms, compares its study, examines the nature and aims of the science and the esteem accorded it. He even finds scriptural support for the study of the heavens in the declaration of the Psalmist that he "was made glad through the work of the Lord and rejoiced in the works of His hands." (7.25—29) The opinions of Plato and Ptolemy both provide additional testimony to the importance of the art.

In another astute rhetorical move, Copernicus points out the remarkable contribution of Ptolemy, who brought astronomy "almost to perfection," but notes that he must diverge from the latter's teachings because some things are not in accord with his system and other motions have been discovered "which were not yet known to him." (8.10) Thus Ptolemy is included in the encomium and his work is given the respect expected.

At the end of the introduction, Copernicus remarks that the task he has undertaken is quite difficult, and that he finds he must diverge from the work of his predecessors to resolve the problems that remain. But in a graceful acknowledgment he adds, "I shall do so thanks to them, for it was they who first opened the road to the investigation of these very questions."

Copernicus continues to employ a conversational tone in the first book, whose purpose, he explains, is to give a general description of the universe. The rest of the work is devoted to correlating the movement of the earth with other celestial bodies. Since the arguments are heavily mathematical in the remaining books, we will be concerned only with the first.

In *De revolutionibus*, as in many other printed works intended for a wide readership that extended outside the confines of the studium or university, one finds that the arrangement and style of the disputation no longer dominates the format. Even though the subject is conceived of in dialectical terms, the writing is more discursive than writing on controversial subjects in the Middle Ages; this change is attributable partially to the recovery of classical letters and literature and partially to the Humanists' desire to put what they saw as the eristic use of the disputation behind them.[13] In most of the universities the Peripatetics still held chairs of importance and through them scholastic influences continued to be felt. Thus, the practice of stating the proposition, objections to it, responding to the major and minor premises of syllogisms, offering concessions or qualifications, are still just as prominent in their published works as they were in the teaching materials already discussed.

Throughout the first book Copernicus proceeds dialectically, doing so in a natural and fluent style. He treats alternative opinions regarding issues, and refutes views opposed to his own through premises based on accepted principles or upon observation. He often alludes to authorities to buttress his position and occasionally uses analogies to clarify his thought. Among the questions or problems he addresses are those regarding the shape of the universe and the earth, the movement of the celestial bodies, the motion of the earth and its position. I have analyzed these arguments and have found his use of various dialectical *topoi* extensive, ranging from genus and property to causation. There is not space enough here to illustrate these, but in general in the first nine chapters their function is to furnish premises for a refutation of earlier opinions on the immobility of the earth.

In the tenth chapter Copernicus turns to a consideration of the order of the orbits of the planets. At this point his arguments become increasingly mathematical as he lays bare the inadequacy of previous explanations. The general argument is still dialectical, but the premises, which in turn stand on further mathematical arguments, occasionally contain demonstrations. In an almost apologetic tone, Copernicus notes

> All these statements are difficult, and almost inconceivable, being of course opposed to the beliefs of many people. Yet, as we proceed, with God's help I shall make them

> clearer than sunlight, at any rate to those who are not unacquainted with the science of astronomy. (21.1—4)

In the middle of this chapter, he again turns to rhetoric to prepare his audience for a conversion in their orientation toward the earth as center of the universe to the sun:

> At rest, however, in the middle of everything is the sun. For in this most beautiful temple, who would place this lamp in another or better position than that from which it can light up the whole thing at the same time? For, the sun is not inappropriately called by some people the lantern of the universe, its mind by others, and its ruler by others. [Hermes] the Thrice Greatest labels it a visible god, and Sophocles' Electra, the all seeing. Thus indeed, as though seated on a royal throne, the sun governs the family of planets revolving around it. (p. 22)

The reference to the hermetic corpus recently translated by Ficino and to Sophocles' *Electra* reveals the humanist in Copernicus, even though he errs in citing *Electra* rather than *Oedipus at Colonus*. What an interesting mixture the work contains in its juxtaposition of the rhetorical, the literary, the dialectical, and the mathematical!

In the very next chapter, Copernicus presents "a demonstration" of the triple motion of the earth. He proposes that this explanation is the answer to the question of the movement of the heavenly bodies and supersedes the received prescription of ten spheres in motion around the earth, which we have already encountered in the commentaries on Aristotle's *De caelo*. Surprisingly, it seems that Copernicus does not dismiss the existence of spheres altogether, and seems to still think of the planets as imbedded in them. Yet he does not comment upon their being composed of the quintessence.

One of the expurgations of *De revolutionibus* ordered by the Church was a change in the title of the eleventh chapter from "A demonstration of the threefold motion of the earth" to "On the hypothesis of the threefold motion of the earth and its demonstration."[14] The interpolation of "hypothesis" was ordered to show the hypothetical nature of Copernicus's work, so that the latter part of the title "and its demonstration" would be understood as a demonstration only if one granted that hypothesis. The demonstration he presents is an argument based on geometrical suppositions that show how the movements ascribed to the earth can be made consistent with observed phenomena.

The remaining four chapters of book one are devoted to computations of the earth's movement and to the geometrical principles employed in the remaining five books. Copernicus is not interested in showing that the geometry he uses accords with the physical reality, as both Galileo and Kepler would later be. In other words, he does not offer physical evidence that the earth revolves on its axis nor that it moves around the sun. As Alexandre Koyré comments:

> A modern reader could express surprise at the complete absence of physical arguments in favour of the Earth's motion. . . . Copernicus certainly gives none. In fact, he could not give any. We much admire — as did Galileo — the power and boldness of this mind, which by pure intellectual intuition was able to overcome all the obstacles that had impeded the advance of ideas.[15]

Aristotle had noted that the earth's movement around the sun could not be conjectured because of the absence of observations of stellar parallax. Since this phenomenon was still not discernible with existing instruments in Copernicus' day, the Polish astronomer may have believed that the nature of proof was limited to dialectical arguments resting on reasoned opinion and on mathematical argumentation.

KEPLER AND GALILEO

Johannes Kepler was the first to ask for actual physical evidence for the Copernican thesis, which he thought would provide an understanding of the geometrical nature of the universe. He did so in his *Mysterium cosmographicum*, published in 1596.[16] Such evidence would change the nature of the debate on the central question of the earth's movement from a question with alternative dialectical answers to a question with one answer alone, and that a certain conclusion deducible from a necessary demonstration.

Meanwhile, in the *Mysterium*, Kepler proposed an ingenious dialectical proof for the Copernican thesis based on geometry. He envisioned that the orbits of the planets occupy spheres that are alternately inscribed within, and circumscribed around, the five perfect polyhedra of classical geometry, arranged in interesting fashion about the sun as a center. He thought that this discovery revealed the design of the Creator:

> The earth's orbit is the measure of all things; circumscribe around it a dodecahedron, and the circle containing this will be Mars; circumscribe around Mars a tetrahedron, and the circle containing this will be Jupiter; circumscribe around Jupiter a cube, and the circle containing this will be Saturn. Now inscribe within the earth an icosahedron, and the circle contained in it will be Venus; incribe within Venus an octahedron, and the circle contained in it will be Mercury. You now have the reason for the number of planets.[17]

Of course the design was in time to prove erroneous, but as Owen Gingerich notes, "Seldom in history has so wrong a book been so seminal in directing the future course of science."[18]

The major issue in the work is the realism of the Copernican thesis. To establish this Kepler compares the reasoning of Copernicus with that of Ptolemy to the advantage of the former. Showing his own dependence on dialectics, Kepler analyzes the argument for its material basis and points out the *topoi* from which it is drawn. He says that Ptolemy's argument rested on a false middle when he assumed that what caused the genus, caused the species, arguing from a specific nature and not from the cause. So Ptolemy offered an argument for the motions of the spheres without really presenting proof. Copernicus, on the other hand, proposed one constant cause for the appearances, viz., the mobility of the earth.

Kepler, then, is concerned to rest his opinion about the Copernican thesis on mathematical computations and physical observation. He longs for the development of necessary demonstrations grounded on physical proof that will permanently decide the question. Another of his works, the *Astronomia nova* of 1609, carries forward this concern and culminates in his discovery of the elliptical orbits of planets. It is on the reverse side of the titlepage of this work that he discloses publicly that Osiander was the real author of the anonymous foreword of *De revolutionibus* and that Osiander had deliberately misrepresented Copernicus's conception of his book.

Kepler also employs rhetorical techniques in his scientific treatises, generally to frame his discourse or to clarify his thought through figures of speech. I say "generally" because he did write an answer to a polemic against his mentor Tycho Brahe, in which his considerable rhetorical skills are exercised throughout. The text has been analyzed by Nicholas Jardine, who carefully describes the dialectical and rhetorical ploys of the work. Moreover, Kepler's writing does have a continuous ethical appeal that is perhaps unconscious, if such is not a contradiction in terms. His tone of direct child-like simplicity and enthusiasm conveys the image of a truth-seeking prodigy, and this is disarming and convincing in its effect. Whether proceeding from act or nature, however, his *ethos* is not a factor that figures in the foundation of his scientific arguments.

The contrary is the case in some of Galileo's writings on the Copernican thesis. He uses rhetorical appeals more extensively than either Copernicus or Kepler. He does so not because he did not know or respect the canons of scientific argument, but because he wanted to convince his audience that Copernicus was right. By the time he wrote, the Copernican thesis had become a major problem for theologians. The discoveries with the telescope he had described so vividly in the *Siderius Nuncius* of 1610 made it impossible to ignore the opinions of Copernicus, as Carbone had done in his commentary on *De caelo*, or to dismiss it as knowingly, as Galileo's exemplar had done some twenty years earlier.

Already in his work of 1610 Galileo had forecast his concern to prove the Copernican thesis. He announces that he will do so in a forthcoming book:

> Let these few remarks suffice us here concerning this matter, which will be more fully treated in our System of the world. In that book, by a multitude of arguments and experiences, the solar reflection from the earth will be shown to be quite real — against those who argue that the earth must be excluded from the dancing whirl of stars for the

specific reason that it is devoid of motion and of light. We shall prove the earth to be a wandering body surpassing the moon in splendor, and not the sink of all dull refuse of the universe; this we shall support by an infinitude of arguments drawn from nature.[19]

Galileo's use of rhetoric in this passage highlights the benefits to man's psyche that would accrue from this new way of looking at the earth. But the splendor that earth will gain is not meant to furnish a sufficient reason for accepting the Copernican thesis. No, Galileo has said he will prove it through logical arguments (Lat., *rationes*) and experiences (Lat., *experimenta*), meaning by the latter expression physical proof.[20]

Unfortunately demonstrative proof eluded him, just as it had Kepler. As I have noted in two recent essays, however, Galileo strongly implied, and even claimed in some passages of his famous *Letter to the Grand Duchess Christina* (1633), that he did have such proof.[21] This letter was written in 1615 and widely circulated in Rome in the hope that it would convince the authorities not to condemn the thesis. Ostensibly addressed to the mother of his patron, Cosimo II de Medici, the letter was actually aimed at a wider public of influential lay and clerical figures. It spoke of the discoveries recently made with the telescope as furnishing necessary demonstrations of the Copernican system. Galileo makes repeated references to these proofs, thus establishing them as facts in the minds of his readers. Opposition to Copernicus he attributes to mean-spirited reaction to his own work, declaring that no objections had followed the publication of *De revolutionibus*.

Yet now that manifest experiences and necessary proofs have shown them to be well grounded, persons exist who would strip the author of his reward without so much as looking at his book, and add the shame of having him pronounced a heretic. All this they would do merely to satisfy their personal displeasure conceived without any cause against another man [Galileo himself], who has no interest in Copernicus beyond approving his teachings.[22]

Mixing indignation with scorn, Galileo continues to undercut the opposition and to maintain that incontrovertible scientific proof stands behind him. Moreover, in light of these purported demonstrations of the reality of the system, he calls for a reinterpretation of passages from Scripture that contradict these truths.

The discoveries did furnish evidence for a partial demonstration of the thesis, as I have elsewhere explained. For example, the supposition that Venus circles the sun is founded on telescopic observations of the planet's crescent phases and its change in size as it recesses or processes. In the same way, the supposition that not all heavenly bodies rotate round the earth is founded on the movement of the satellites around Jupiter. Not so clearly shown, however, are proofs for the supposition that the earth rotates on its axis and revolves around the sun. Today, the movement of the Foucault pendulum provides a firm foundation for the supposition of the earth's rotation, and observations of stellar parallax undergird the supposition of the earth's annual rotation around the sun. But neither of these proofs was available to Galileo.[23]

The reason for his exaggeration of the evidence was, no doubt, because he had a clear perception that Copernicus was right and that what he had seen with his own telescope corroborated that view. But scientists of the day, many of whom were clerics and theologians as well, were wary of accepting a conclusion that seemed to overturn the Scriptures. They were more inclined to accept the solution proposed by Tycho Brahe, who thought that the earth remained unmoved but that the planets revolved around the sun, which in turn moved with its planet satellites around the earth. This permitted the Scriptural passages to stand inviolate. The Roman Catholic Church was especially desirous of conserving its traditional views in the face of the recent secessions of Protestant sects throughout Europe. But Protestants were not eager to accept the new view either, and Luther himself condemned the Copernican thesis. Given the conservatism of the majority of intellectuals in positions of authority in universities, churches, and states, the scientist had to present evidence that would be recognized as utterly convincing. This could only be accomplished by following the canons of the day. Realizing this Galileo tried to finesse the issue by assuming a *fait accompli.*

After the Church banned the advocacy of the Copernican conception of the cosmos and ordered the expurgation of *De revolutionibus* to read "hypothesis" instead of "thesis," Galileo ceased for a time to promote the cause. Thinking that the new pope and an early admirer, Urban VIII, would look more benignly on a dialectical exercise where arguments for the competing systems could be developed, Galileo published his *Dialogue Concerning the Two Chief World Systems* in 1632.

This was the long-promised "System of the World," wherein he did, in fact, show the superiority of the Copernican view by logical arguments and demonstrations, although by this time he was to claim in his preface only to be entertaining a "pure mathematical hypothesis." He was ingenious in selecting the dialogue format so that opposing opinions could be fully aired and refuted. Besides showing him to be a master at the art of dialectics, the work also proves him to be a consummate rhetorician as well. It is replete with rhetorical techniques of argumentation and presentation.[24]

Despite the preface's disclaimer to offer only a "pure mathematical hypothesis," one of his proofs for the Copernican system was proposed as necessary: the argument from the tides. Galileo presents the movement of the tides as proof of the earth's rotation, and he seems to have believed that it did offer irrefutable confirmation. In this, he ignored Kepler's assertion that the moon's pull is responsible for the tides. Nevertheless, he had proposed this proof to Pope Urban in an interview some time before, and Urban reportedly asked Galileo to consider another possibility: that God through his absolute power could have made the tides move by other means. That is to say, that the earth's movement does not have to be posited as the cause of the tides should God wish the earth to remain stable, which raises again the question of God's absolute power already encountered in the commentaries on *De caelo*.

Acceding to Urban's wishes Galileo does have one of the interlocutors in the *Dialogue* counter the demonstration from the tides with the Pope's proposal. The problem was that Galileo chose Simplicius, the pedantic follower of Aristotle who was repeatedly bested in the *Dialogue*, to articulate that position.

Thus, the use of what might be termed an example of the rhetorical fallacy of "poisoning the well" succeeded in reducing the effect of the argument in the *Dialogue*, but at the price of infuriating Urban. The examiners appointed by the Church selected that passage in particular as showing Galileo's contempt for theological opinions.

Galileo's combined use of dialectics, demonstration, and rhetoric was so persuasive that the Church had little alternative but to determine that he had violated its ban against teaching the Copernican system. Some Catholic scientists, however, were more critical of his methods than of his "heresy." They were not convinced that the argument from the tides was really demonstrative, but were looking for the astronomical proofs he had promised and were unmoved by the rhetoric he employed. Antonio Rocco, a philosopher who had studied at the Collegio Romano, voices his frustration:

> But come on, if there is a necessary truth and conclusion such that it is also evident as you say, show the evidence, bring in the reasons and the causes, leave persuasion to rhetoric, and no one will contradict you.[25]

The reason for the shift away from reliance on the canons of scientific reasoning observed through the centuries was that scientific questions now touched on a matter of public concern. To ban scientists from considering questions because they might contradict the truths of religion was to move the issue from the domain of pure science, where questions of what is the cause were debated, into the world of practice, where questions of what should be done were considered. True to its history, rhetoric again became the handmaid of necessity.

NOTES

[1] The point is discussed at length in my "The Interplay of Science and Rhetoric in Seventeenth-Century Italy," *Rhetorica* 7 (Spring 1989), 23–43; and in a book in progress,

The Case for Copernicus: Rhetoric in the Cause of Science and Religion. See the analysis of reasoning in Galileo's *Dialogue Concerning the Two Chief World Systems* by Maurice Finocchiaro, *Galileo and the Art of Reasoning: Rhetorical Foundations of Logic and Scientific Method* (Dordrecht and Boston: Reidel, 1980).

[2] Wallace's most recent discussion is in "The Dating and Significance of Galileo's Pisan Manuscripts," in *Nature, Experiment, and the Sciences: Essays on Galileo and the History of Science in Honour of Stillman Drake* (Dordrecht-Boston: Kluwer, 1990), 3—50. Wallace has described the source of the logical questions in his introduction to and commentary on MS 27, which was transcribed by William F. Edwards, *Tractatio de praecognitionibus et praecognitis* and *Tractatio de demonstratione* (Padua: Editrice Antenore, 1988). An earlier discussion of both manuscripts is in his *Galileo and His Sources* (Princeton: Princeton UP, 1984).

[3] "The Rhetoric Course at the Collegio Romano," *Rhetorica* 4 (Spring 1986), 137—151.

[4] I am indebted to William A. Wallace for the English translation, which he is preparing for publication. Page references in my quotations are to those of the manuscript.

[5] Aristotle, *The Art of Rhetoric*, Trs. John Henry Freese. (Harvard UP, 1975), I.2.1358.a.

[6] Benedict M. Ashley, *Aristotle's Sluggish Earth: The Problematics of the "De caelo"* (River Forest, Ill.: Albertus Magnus Lyceum, 1958), 18. This work is also published in *The New Scholasticism* 32:1 (January 1958), 1—32; and 2 (April 1958), 202—234. I have referenced the first cited here.

[7] *Ibid.*, 11—22.

[8] So as to simplify the citations I have placed page or folio references in the text. The sources for these are the following. Galileo's MS 46 has been transcribed and translated by William A. Wallace, *Galileo's Early Notebooks: The Physical Questions* (Notre Dame: Notre Dame UP, 1977). Wallace has also provided a valuable introduction and commentary. I have cited this text in my discussion. My references to Carbone's manuscript are also to a translation Professor Wallace has made of the text I discovered. A description of the manuscript will appear in my "Ludovico Carbone's Commentary on Aristotle's De caelo," in *Nature and Scientific Method*, a festschrift in honour of William A. Wallace, (Washington: The Catholic University of America P, forthcoming).

[9] The reference to Boethius is found in Book III, Part 9. I have given the translation by V. E. Watts, *The Consolation of Philosophy* (London: Penguin, 1969), p. 97.

[10] See the discussion of the arguments in Ashley.

[11] I have used the translation and commentary of Edward Rosen, Copernicus, *De Revolutionibus* (Baltimore: Johns Hopkins UP, 1978).

[12] Ptolemy's preface, *The Almagest.* Trs. R. Catesby Taliaferro. Great Books of the Western World, Vol. 16 (Chicago: Encyclopaedia Britannica, 1952).

[13] Neal Gilbert describes the Humanists' approach to method in *Renaissance Concepts of Method* (New York: Columbia UP, 1960), pp. 76—77. See also his analysis of attitudes toward the disputation in "The Early Italian Humanists and Disputation," *Renaissance Essays in Honor of Hans Baron.* A. Molho and J. A. Tedeschi, eds. (Florence: Sansoni, 1971).

[14] The emendations required by the Sacred Congregation are listed in *Le Opere di Galileo Galilei*, ed. Antonio Favaro, 20 vols. in 21 (Florence: G. Barbera, 1890—1900, rpt. 1968), 19:400—401.

[15] Alexandre Koyré, *The Astronomical Revolution*, R. E. W. Maddison, trs. (Ithaca: Cornell UP, 1973), p. 54.

[16] Owen Gingerich points this out in his article on Kepler in the *Dictionary of Scientific Biography*, Vol. 7: 289—312; 290—291.

[17] Gingerich quotes Kepler, 290.

[18] *Ibid.*, 292.

[19] My citations are to the translation of the *Siderius nuncius* by Stillman Drake in *Discoveries and Opinions of Galileo* (New York: Doubleday, 1957), p. 45.

[20] *Opere*, 3, part 1:75.9.
[21] See my discussion in "Galileo's *Letter to Christina*: Some Rhetorical Considerations," *Renaissance Quarterly* 36 (Winter 1983), 547—583 and "The Rhetoric of Proof in Galileo's Writings on the Copernican System," in *The Galileo Affair: A Meeting of Faith and Science*, eds. G. V. Coyne *et al.* (Vatican City: The Vatican Observatory, 1985), 41—65, reprt in *Reinterpreting Galileo*, W. A. Wallace, ed. (Washington: The Catholic U of America P, 1986), 179—204.
[22] *Discoveries*, p. 179.
[23] Moss, *Rhetoric of Proof*, 183.
[24] I discuss the Dialogue in "Galileo's Rhetorical Strategies in Defence of Copernicanism, *Novita celesti e crisi del sapere*, Paolo Galluzzi, ed. (Florence: Istituto e Museo di Storia della Scienza, 1983), pp. 95—103.
[25] Quoted in Adriano Carugo and Alistair C. Crombie, "The Jesuits and Galileo's Ideas of Science and Nature," *Annali dell' Istituto e Museo di Storia della Scienza di Firenze* 8 (1983): 24, citing Opere 7:629.