Saket Vora
HI 322 Sec. 001
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Dr. Kimler

Copernicus and the *Revolutionibus*

The publication of the *Revolutionibus Orbium Coelestium* (On the Revolutions of the Heavenly Spheres) by Nicholas Copernicus was a crucial step in a long chain of events that set into motion the 'scientific revolution' of the 17th century. It was the first work to seriously re-introduce the notion of heliocentrism to scholarly debate in Europe, inspiring future learned men such as Galileo Galilei and Johannes Kepler to carry on and expand the theory. The role of the *Revolutionibus* is not that of a brazen opening salvo against the Ptolemaic system, but instead a delicate push towards physically freeing the Earth from its rigidly stationary place in the cosmos. This paper explores the motivations of Copernicus to write his *Revolutionibus* and the justifications he states for affirming his theory.

To understand what propelled Copernicus to a new theory one must understand the context of his times. Since the 2nd century CE, the system of the world proposed by Ptolemy in *The Almagest* was the established description of the heavens, in no small part due to its acceptance by the Catholic Church which was Europe's primary political, religious, and scholastic institution throughout the medieval period. This system was firmly grounded in the logic of Aristotle and other Greek philosophers, with an emphasis on the heavens' unchanging cosmic order and perfection.[1] It consisted of an unmoving Earth at the center of the Universe, surrounded by spinning concentric crystalline spherical shells which contained the celestial bodies with a fixed outer shell containing the starry field. The Sun occupied the shell between Venus and Mars.[2] Ptolemy's model was able to predict the motions of the sun, moon, and planets well enough at the time to be used to create a calendar. Thirteen centuries later however, the inaccuracies inherent in the model and expressed via the calendar were becoming too apparent to ignore. The dates on which to celebrate Easter and other religious days, which had historical seasonal or astronomical significance, were deemed suspect and there were several efforts by the Vatican to reform the calendar. Copernicus was invited to one of these reform councils in 1514, so the inaccuracies of the prevailing model in predicting planetary motion were known to him.[3] Copernicus, by this time a skilled mathematician, was aware of not only Ptolemy's original model, but a multitude of variations of it that astronomers over the years introduced as knowledge from Arab scholars more observational data (not always accurate) became available. Observational data was also unsatisfactory, as Copernicus notes that even the length of a complete year has not been precisely measured.[4] In the preface of the *Revolutionibus* addressed to Pope Paul III, he briefly states several models and their flaws, such as inconsistent uses of eccentrics and concentrics as well as uses of eccentrics and equants that violate the Aristotelian principle of the uniformity of motion. Copernicus "began to grow disgusted that no more consistent scheme of the movements of the mechanism of the universe, set up for our benefit by that best and most law abiding Architect of all things, was agreed upon by philosophers."[5] Thus, the primary motivation for Copernicus to formulate and present a new theory was to "solve the problem of the planets."[6] He was encouraged by his colleagues and friends to publish his work and says to the Pope that he might "contribute something to the ecclesiastical state whose chief office Your Holiness now occupies."[7] The remainder of the preface and books of the *Revolutionibus* is devoted to providing historical, logical, and mathematical justifications for his theory.

Copernicus began his investigation by studying the works of all the philosophers who have opinionated on a structure of the Universe that differed from the view taught by current scholars. In particular, Copernicus mentions Niceta of Syracuse, Philolaus the Pythagorean, Heraklides of Pontus, and Ekphantus the Pythagorean as ones who postulated the movement of the Earth.[8] It is no coincidence that these philosophers were of the ancient world, living in the 5th and 4th century B.C. Contemporary European scholastic learning and even the very idea of what constituted 'knowledge' had its roots in the ancient world, built upon the foundation of Socrates, Plato, and Aristotle.[9] To lend greater credibility to his theory, Copernicus looked towards the contemporaries of Plato and Aristotle and showed that even the venerable ancients were not in agreement about the Earth's movement. Beginning his defense with this observation, Copernicus both denies his critics a quick way to discredit the basis for his theory and distances himself from being a true maverick; he is not the originator of the moving Earth theory, but is simply building upon an existing but long discarded idea. The second argument he provides stems from Aristotelian logic, namely a return to the principal of uniform circular motion that the perfect and pure heavens surely adhered to. It had been long known that the planets did not appear to have the same regular motion as the moon, the sun, or the stars. Planets would vary in the size of their appearance and even stranger, some would even appear to go backwards for a period of time before continuing on its usual course. Ptolemy introduced the epicycle to fix this, but in order for the mathematics to work he did not center the epicycle's orbit of revolution with that of the Earth, but of a point between the Earth and that orbit's *equant*. The equant was the point of reference that the planet maintained uniform circular motion. To complicate this further, celestial bodies used different equants and epicycles. While the mathematics for this will not be delved into here, Copernicus demonstrated that an unavoidable consequence of using equants was the non-uniform motion of the spheres.[10] Thus, Copernicus attempts to appeal to his critics' Aristotelian sensibilities in trying to show that his theory actually adheres to Aristotle's logic and order of the cosmos better than Ptolemy's. Later in the preface, after explicitly stating his order of the planets in a heliocentric universe, Copernicus says that "in this arrangement…we discover a marvelous symmetry of the universe, and an established harmonious linkage between the motion of the spheres and their size, such as can be found in no other way."[11] Once again, Copernicus emphasizes how his theory preserves the ancient belief of inherent beauty and symmetry that the cosmos was thought to physically display. A theory for the universe could now both be mathematically accurate and physically convincing. What about the specific motion of the Earth? Here Copernicus returns to the primary purpose for exploring the topic – to solve the problem of the planets. Though the mathematics are found in later sections, Copernicus shows that the backwards and forward motions of the planets and the variation in observed size all "proceed from the same cause, which is the Earth's motion."[12] The real advancement of Copernicus was to use mathematics to demonstrate that the planetary phenomena were due to *apparent* movement as observed from a moving Earth.[13] Furthermore, not only did his theory predict the motions of the celestial bodies just as well as Ptolemaic models, but it offered a physical basis for these predictions in a manner that qualitatively appeared more symmetric and orderly.

Ultimately, the full exposition of the Copernican model proved unconvincingly simpler or more practical than the Ptolemaic models. Despite this outcome, Copernicus was successful in demonstrating that a moving Earth model for the universe showed promise in solving the problem of the planets – an achievement seen in the works of future astronomers. Encouraged by his colleagues and from a desire to bring cohesion and order to a multitude of varying theories, Copernicus presented a new theory that was supported by historical inquiry of ancient philosophers, grounded in the logic and principles of Aristotle, and mathematics that demonstrated the practical advantages that a moving earth had in physically explaining planetary observations. The *Revolutionibus* served as a crucial transitional work that eased the acceptance of heliocentrism in Europe, and for that Copernicus is duly remembered.

Works Cited

1. Kimler, William. 28 Aug. 2006, 30 Aug. 2006, 1 Sept. 2006. "Lectures on the Rise of Modern Science," Raleigh: North Carolina State University.

2. Kuhn, Thomas. *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*. Harvard University Press, Massachusetts. © 1957, pg. 53.

3. Kusukawa, Sachiko and Liba Taub, *et al*, editors. "Copernicus and Calendar Reform". Starry Messenger Project. Department of History and Philosophy of Science of the University of Cambridge. URL: http://www.hps.cam.ac.uk/starry/copercalen.html © 1999-2000.

4. Copernicus, Nicholas. *On the Revolutions of the Heavenly Spheres*, *Preface.* Translated and re-printed. Hosted online by William Kimler. URL: http://legacy.ncsu.edu/classes/hi322001/derevpre.htm © 2005 (1543 original Latin)

5. Copernicus, *the Revolutions of the Heavenly Spheres*, *Preface.*

6. Kuhn, *The Copernican Revolution*, pg. 136.

7. Copernicus, *the Revolutions of the Heavenly Spheres*, *Preface.*

8. Copernicus, *the Revolutions of the Heavenly Spheres*, *Preface.*

9. Kimler, "Lectures on the Rise of Modern Science."

10. Kuhn, *The Copernican Revolution*, pg. 148.

11. Copernicus, *the Revolutions of the Heavenly Spheres*, *Preface.*

12. Copernicus, *the Revolutions of the Heavenly Spheres*, *Preface.*

13. Kuhn, *The Copernican Revolution*, pg. 150.

Works Consulted

Stimson, Dorothy. *The Gradual Acceptance of the Copernican Theory of the Universe.* Peter Smith, Gloucester, MA. © 1972 (1917 original)

Vollmann, William T. *Uncentering the Earth*. Atlas Books. W. W. Norton & Company, New York, NY. © 2006