The New Star of 1572 and the Ascendancy of the Mathematical over the Causal Epistemology of Natural Philosophy

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The New Star of 1572 and the Ascendancy of the Mathematical over the Causal Epistemology of Natural Philosophy

by

Douglas Godley

A dissertation submitted to the Graduate Faculty in History in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York 2014
This manuscript has been read and accepted for the Graduate Faculty in History in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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THE CITY UNIVERSITY OF NEW YORK
Abstract

The New Star of 1572 and the Ascendancy of the Mathematical over the Causal Epistemology of Natural Philosophy

By

Douglas Godley

Advisor: Professor Joseph Dauben

The arrival of the new star of 1572, the first nova recorded in the western canon of natural philosophy, startled and challenged the scientific community of the age. As they worked to observe and to understand the nature of this new star, astronomers across Europe quickly discovered that the traditional intellectual tools that they had come to respect and rely upon when observing the heavens were by and large useless in helping them to gather data, and thus to come to conclusions about the star’s location, its physical nature and its meaning. In the records that contemporaries have left, modern readers may see how the nova’s observers quickly adapted new tools and revised old theories in an effort develop satisfying answers to the questions the nova’s arrival forced them to ask. The literary records and physical artifacts of the star’s fourteen month long visit also reveal the extent to which natural philosophers had begun to distrust and even to jettison the
fundamental tenets of the millennia old epistemologies that had guided their basic beliefs in the ways in which the cosmos was to be understood. In these reports and letters, readers will find technical accounts that will also help them to gauge how far those observers had moved towards the acceptance of an epistemology based upon the values of experiences, observation and mathematical analysis. Nova observers of the post Copernican half century, it will be seen, were flexible and independent thinkers; open to new theories and intellectual crosscurrents. They were also active gathers and disseminators of natural knowledge, as well as members of the continent wide network of scientific investigators; responding to the age's onrush of new information, new technologies and experiences.
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Chapter One
The First New Star:
Astronomy after *De revolutionibus*

No fundamental astronomical discovery, no new sort of astronomical observation, persuaded Copernicus of ancient astronomy’s inadequacy…Until half a century after Copernicus’ death, no potentially revolutionary changes occurred in the data available to astronomers.

*Thomas Kuhn*

Sometime around the year 8,500 B.C.E., a star of medium size inhabiting one of the spiral arms of our galaxy came to the end of its life. Like others of its kind that had and would mimic its fate, the star in question had been hollowing itself out for millions of years and, finally, collapsed upon its own gravitational weight. In doing so, it set off a nuclear detonation. From its innards, it threw out an entire periodic table of elements that had been cooked up inside its burning core over the millions of our years that constituted the age of its life. It also broadcast out into the vast expanses of space an ever-expanding sphere of electromagnetic radiation, across the entire spectrum of frequencies, of almost unimaginable energy.

That avatar of the star’s self-destruction, a yearlong flash of radio waves, spread out in all directions. Even traveling as fast as it physically could, 186,000 miles per second; it was 10,000 years before the now faint remnant of that burst of energy began to wash over the planets of our solar system.

For most of the inhabitants of our world, the arrival of the waves of light might well have gone unnoticed. Many people living at the time would have had no means of leaving a record of their observations for posterity to discover even if they had. Astronomers and astrologers in a very few countries like China, that did have the inclination and the tools to take note of what they saw, dutifully recorded what they had observed and, one may imagine, immediately set out to decipher its meanings in accordance with the received wisdom that made up their canon of knowledge.

On that spit of land extending westward from Asia that locals had the temerity to call the continent of Europe, however, there was a different response. As did the Chinese, educated men there who had made it their business to observe events in the heavens rushed to record what to them appeared to be a new star; in a part of the sky they called the constellation of Cassiopeia. Not all so engaged sought simply to add its apparent reality to the scrolls of now ancient and well-understood knowledge, however. For some the event of the waves’ arrival had sinister, even frightening connotations. For others, it seemed to be just the messenger that they might have dreamed of. For many, its very existence was simply a collection of contradictions and impossibilities.

That largely intelligent and similarly educated people, thoughtful, well-intentioned and experienced in their professions, might take the bright new light in the sky to have many different meanings is symptomatic of the intellectual tenor of the age in which it arrived, as well as a measure of the magnitude of what they were seeing: that notice of a star’s demise ten thousand years before arrived here on Earth in the late fall of the year we record as 1572, a time of religious struggle and philosophical ferment. Its
meanings and messages came in the form of what we now call a supernova, to contemporaries a “new star,” an object appearing, it seemed to most in the West at that time, in the realm of the heavens, where, many people were sure, nothing would or could ever change, and nothing like this could ever happen.

Educated Europeans of the age are well understood to have had their theories of how the universe worked and what its existence meant. They were after all the products of centuries of intellectual challenge and academic development. This was the crux of the problems they faced when they thought about the new star shining brightly above them: the visitor then residing in Cassiopeia seemed to have arrived in complete defiance of their best, most ancient and revered explanations of the movement and structure of the heavens as to why it could not possibly be where it so obviously seemed to be. Within the entire body of western science no such new star had ever been positively observed or recorded.

With so little to work with; only a point of light seemingly well beyond the realm of their collected and collective experiences, and such a confusing and even frightening event to explain, scholars, intellectuals, political and religious leaders, the curious, all fell into debate using the best tools at hand: the broader pictures of the world that they had learned about in the courses of their educations and held as truth; the assumed purposes of these; the apparent logic and reasoning that all were sure ultimately came from a wise and rational God.

As if the nova’s arrival wasn’t intellectually challenging enough, the star’s bright white light, visible at first even in the daytime, lasted 14 months and then just faded away, occasionally flickering and changing its color as it grew dimmer. By the late spring
of 1574, not a ray of light came from the spot that the star had occupied just months before.

This thesis is about the discussion and debate that the arrival of the nova of 1572 ignited. I suggest that an examination of surviving records of that event, focusing on its observers’ ideas about how it got there, what it meant, what it couldn’t mean, even where it really was, has much to tell us about how astronomers in particular and the natural philosophers of the age in general acquired new information, how they came to conclusions about that information, and therefore much about the nature of scientific discovery at the end of the sixteenth century. I argue here that in the contemporary response to the new star, in the discussion and debate it engendered, modern students of the subject of late sixteenth-century natural philosophy should discern an important shift in the priorities of the means in which its investigators came to collect and understand knowledge about an object in question: away from their time honored reliance upon received logical and geometric methods of deductive understanding, the ways presented to them by their classically based educations, and towards that of an observational approach to the understanding of natural phenomena that relied for its conclusions less upon the theoretical mathematical constructs of ancient scholars, as upon mathematically and observationally derived facts.

This shift was by no means new in 1572. By the middle decades of the sixteenth century, virtually every field of natural philosophy outside of astronomy that might impinge upon the reception of the nova was in the process of experiencing a similar reorientation. Through out the previous one hundred years, practitioners of natural philosophy had been repeatedly challenged by the failures of their classically founded,
literarily based traditionalist perspective, sometimes called by modern scholars the
“Venerable Tradition,” and in response, had shifted their efforts towards an more activist,
observationally based, rapidly mutating, collective enterprise. While respecting and
relying upon their intellectual inheritance, observers of the natural world in 1572 had
learned long before the arrival of the nova to listen to and also to respect new opinions
and ideas about the nature of the universe they saw around them. They readily sought out
the use of new tools and methods to aid in their investigation of that universe. Here I will
describe these and show that those same new tools and methods, heretofore almost
exclusively reserved for terrestrial research, played an as essential part of the
investigation of the nova, more productively so than did the traditional means by which
members of educated society had come to understand the world around them and the
heavens above.

Specifically, nova observers looked to the newly matured discipline of
trigonometry and also, to instruments like cross-staffs, sextants and globes (all of these
more commonly found in the hands of cartographers and geographers) to answer their
most important questions about the nova, and with demonstrably more faith in the
possibility of finding useful results than the logical methods, arguments and received
traditions of philosophical enquiry that had heretofore supplied their most important
epistemological methods of understanding the universe. If I have made my case, it will be
clear to the reader that, in the aftermath of the new star’s visit, when the two
epistemological models I have described above were examined side by side for their
efficiency and their efficacy in coming to reasonable conclusions, the new methods at
hand, in the eyes of their users, were found to provide better answers. These answers
were better because they, the natural philosophers looking at the nova all agreed, were capable of being proven true. In comparison, it will be shown, classical means of understanding the nature of the nova had in 1572 signally failed.

From the events, ideas and opinions recorded in surviving texts, we can measure the extent to which these new methods were taken up by a considerable part of the age’s community of astronomically inclined natural philosophers. Also visible among the pages of nova reports is the group of observers that were not directly involved in the work of natural philosophy: educated professionals who were otherwise concerned with the many other aspects of governance, of medicine, of finance and of war that made up the careers of literate Europeans across the continent. Finally, one cannot exclude in this list the instrument makers and other craftsmen whose historical artifacts consist of the new instruments they invented and perfected; the tools their clients and masters used to examine the nova, thus also creating for themselves an essential role in the evolution of the science of astronomy in the sixteenth century. In the immediate and unrehearsed response to the new star, and later through reflective comments and the pointed editing of commentators, we may see how observers from all of these diverse backgrounds sought, in response to the strange visitor’s arrival, the best ways to gather what they felt to be reliable data, and later, how those means contributed to the creation of what nova contemporaries considered a more exacting and productive science.

Numerous records of observer’s thoughts and ideas about the nova have survived to mark the event and act as evidence of the debates it engendered. Most importantly for modern students of the subject, the Danish astronomer Tycho Brahe (a central figure in
this thesis) compiled a collection of his fellow observers’ writings which was published shortly after his death, in 1602. His collection lists the opinions of no less than twenty seven astronomers and natural philosophers. Though his was by far the largest, he was not alone in producing such a compilation. The emperor Rudolph the Second’s physician Thaddeus Hagecius wrote an entire book on the subject containing the complete commentaries of several of his colleagues across Europe; the Jesuit mathematician Christophe Clavius, better known for his reforming work on the Julian calendar, discussed it briefly in his 1581 commentary on the *De sphaere* of Sacrobosco. He included the opinions of a number of his Catholic colleagues. English mathematicians John Dee and Thomas Digges simultaneously published books mentioning the nova while it was still visible, as did the Spanish courtier, scholar and mathematician Fra Heronimo Muñez. Long after it had vanished, the nova of 1572 was discussed by Johannes Kepler, Galileo Galilei, and Isaac Newton in their cosmological studies. All of these, and numerous other accounts, survive today as a gauge of the new star’s intellectual impact.

The contents of these works tell us that, at the time of the nova, as might be expected, the science of astronomy (and its sister, the art of astrology) were practiced by a broad range of observers who were all very well aware of the visual appearances, the physical motions of and the longstanding philosophical theories which guided their thoughts about the heavens above. Equally importantly, they also tell us what their less well remembered colleagues and their intellectual predecessors had thought and believed about them. Surviving records tell us that, with not much else to base their conclusions on, the nova’s observers were forced to rely upon oft times confusing and contradictory
evidence placed before them by the new star’s appearance to form their opinions about the visitor in the night sky above them. Their books, pamphlets and prints contain much to demonstrate that they were not afraid to question those very same literary, logical and mathematical rationales that they had received from their ancestors, sources that they had traditionally used to explain the very things that now caused them anxiety and confusion, if these contradicted the evidence of their own senses.

For all their interest in natural philosophical developments in the latter half of the sixteenth century however, twentieth-century historians of science have not provided so detailed a picture of the debate that the new star had engendered among its observers. The events triggered by the arrival of the nova are often, and briefly, mentioned in discussions of the period, but to my knowledge, never delved into at any length, it is clear, that the subject deserves. The scholar most responsible for bringing the nova of 1572 to the attention of contemporary historians of science, C. Doris Hellman, published one short study in 1959, and a further article in 1967. She included more valuable data on the nova in another work that discussed the comet of 1577. Both contain succinct collections of observational results and lists of the individuals who made them, interspersed with her interpretations of these results. Having written these for scholarly journals, Hellman could assume that her readers had some knowledge of the lives, educations, skills, professional relationships and opinions of her subjects. In her brevity however, she excluded the broader professional and private experiences of these figures, whose lives beyond that of the nova turn out to be both interesting and valuable contributions to the study of astronomy and the history of science in general. Many of these observers were

clearly not professional astronomers in the stricter sense of the term that the modern world would use, however, a point which leads me to believe that the scientific communities of the age, however one chooses to define that term, were both broader and more diverse that one in the 20th century might conclude from reading her studies.

I suggest that, in the main, this is because Hellman had been responding to the historical dialog of her time. For their part, her scholarly precursors and contemporaries had been engaged in a lengthy debate over the origins of modern science, with camps divided between, among other things, those who saw modern science as a product of the intellectual milieu of the late Renaissance, and those who saw powerful continuities between the thinkers of that age and medieval natural philosophy. Closely intertwined in this aspect of debate was the place of various intellectual traditions that the west had inherited from the ancient world. By way of example: discussion about the relative places of Platonism and Pythagoreanism, mathematics, on one hand, and the received logical methodology and wisdom of the philosopher Aristotle on the other, played an essential role in the literary and scholarly debates during the years that Hellman studied and wrote.

The historians of science who had been most influential in this discussion focused primarily upon the figures that had traditionally been accorded central positions in the cannon of intellectual history: natural philosophers such as Copernicus, Newton and Galileo, and even earlier, the Merton School mathematicians, and Nicholas Oresme and Jean Buridan. The writings of Bacon, Descartes and Boyle all remained in prominent view. With the collective works of these authors in mind, modern historians could create an “internalist” narrative, one in which the development of scientific philosophies was a
product of a primarily literary milieu, seemingly deeply indebted to and rebelling against
the claims and epistemologies of the cannon of classical authors.

For the founders of the modern discipline of the History of Science, writers such
as E.A. Burt, for example, the ultimate test of (modern) scientific validity lay with the
development of the mathematical methods used by such experimenters as Galileo Galilei
at the beginning of the seventeenth century to describe the motion of falling bodies. In his
_The Metaphysical Foundations of Modern Physical Science_ (1924), Burt made the
historical divergence between the causal epistemology of the Aristotelian tradition, and
the seemingly recent development of mathematical explanation a central act in the
evolution of a philosophy of science. He did this, not so much to create a historical
narrative of the development of science, but to explain why man’s self created image of
his own place in the universe had changed so radically since the Middle Ages. In doing
so he located this shift in the fundamental change in man’s perspective of the universe
that took place in the seventeenth century under the strong influence of the writings of a
handful of scientific practitioners; Kepler, Galileo and Newton to name a few, whose
works were seen as both markers and creators of that great intellectual divide.

Alexandre Koyré, though he came to see much the same process manifest itself
in the works of a broad range of seventeenth-century natural philosophers, also initially
concentrated his analytical energies upon Galileo’s writings. ³ He suggested in his _Etudes
Galileennes_ (first published in 1939) that Galileo be seen as the figure who had realized
the Renaissance project of discovering the hidden mathematical relationships of nature.
Koyré saw in Galileo’s work the seminal triumph of the platonic tradition which had

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³ Koyré (1892 – 1964) may well have been the first to popularize the term “Scientific Revolution.” H.
Floris Cohen, _The Scientific Revolution; A Historiographical Inquiry_ (Chicago: University of Chicago
become a banner for the mathematicization of nature. The great discover of the moons of Jupiter might well experiment with pendulums and rolling balls, but his primary inspiration must have been understood to stem from the literary and intellectual milieu of the Renaissance.

Connections between the humanists’ project of rediscovery and recovery and the experimental work of seventeenth-century experimenters are not hard to find. In his *The Italian Renaissance of Mathematics* (1973), Paul Lawrence Rose described the works of classical mathematicians who had been influential to Galileo’s sixteenth century forbearers. Rose narrated the rediscovery of the works of Archimedes (not for the first time by European natural philosophers), their publication by mathematical practitioners such as Nicoloco Tartaglia, and the efforts of scholars like Guidobaldo del Monte to absorb and build upon re-illuminated classical Greek knowledge. In that del Monte was a mentor to Galileo, Rose and others who sought intellectual continuity would have few hurdles to go over in making direct connections between the legacy of Greek mathematics and the ideas of seminal philosophers and investigators.

Despite classical antecedents and inspirations, a chronological description of the evolution of science might well concentrate upon the short period of time which constituted the experimental career of Galileo Galilei. It would not be hard to see something of a “revolution” in the modern sense of the word in the quick succession of discoveries and mathematical innovations which characterized the work of Galileo, Kepler and their contemporaries. Later, Koyré went on to expand his thesis to include other seventeenth-century figures, making his final published study an analysis of Isaac Newton’s work. Once they had accepted the central concept of a mathematical basis for a
new epistemology, natural philosophers such as Robert Boyle and his fellow experimenters all aimed their efforts at understanding nature from the perspective of mathematical analysis.

The matter of chronology was never far from Koyré’s contemporary historians’ thoughts. In his 1913 Galileo’s Parisian Forerunners, Pierre Duhem had placed the astronomer’s greatest inspiration as far back as the early fourteenth century, in the works of the Paris Terminists.\(^4\) This made the birth of modern science not so much the product of an intellectual discontinuity, limited in chronological length, but rather, an ongoing intellectual evolution, spanning centuries and cultures. This proved a productive path to follow and later writers, such as Edward Grant, Anneliese Mayer and Marshall Clagett were very successful in expanding upon this idea. Grant’s Physical Science in the Middle Ages (1971) is a detailed study of Aristotelian epistemology, and also, an inquiry as to why medieval mathematicians were unable or unwilling to overthrow Aristotle’s causation and replace it with something resembling Galilean mathematical analysis.

If one were to accept the idea that the modern philosophy of science, its epistemological values and perspectives, had been introduced centuries before the birth of Galileo (and had survived that interval to have become an influence upon his thinking), then the historian must search for broader and deeper causes of its creation than from within a narrowly defined set of defined parameters than those delineated by scholars such as Koyré and Burt. One might very well be able to question the idea of a scientific “Revolution” in and of itself. Robert Westfall sought to explain the place of mathematical analysis, experimentation (what he labeled as “Pythagorean”) and another intellectual path, that of the development of the “mechanical philosophy” (his term: “Democritean”),

within an intellectual climate that had accepted Koyré’s mathematical milestones.\(^5\) Westfall saw the intellectual revolutions of the seventeenth century as being a resolution of tensions inherent between these two different perspectives. Keeping his model in view when moving forward through the seventeenth-century “age of revolution,” so to speak, writers could look to the works of Isaac Newton (Westfall’s *Never at Rest* is a standard of Newtonian biography) and find a synthesis of these various strands of scientific investigation in his *Principia*. Those who had developed the ideas and methods pertinent to a mathematized model of nature now could find in Newton’s great work much in common with those who looked to the mechanical philosophers and experimenters of the seventeenth century. Thus, for Westfall, “Newton carried the scientific work of the 17\(^{th}\) century to a plane of achievement which has led historians to speak of a scientific revolution. And modern science continues to pursue its effective course within the framework thus established.”\(^6\)

Through the 1950s and 60s historical models of what was called the Scientific Revolution like those described above continued to evolve and to mature. Discussion about the timing and mechanics of such a revolution centered upon on the primacy of the literary tradition as a benchmark of verity for seventeenth-century investigators, however. And that conceptual path could be extended to considerable distances in time and place. So it was that, in 1957, Thomas Kuhn wrote his influential *The Copernican Revolution*, incorporating in that book the assumptions and conclusions of the several past decades’ research and scholarship. For Kuhn, a physicist, that straight narrative line could be followed, from the work of Claudius Ptolemy, through the ages, to that of Copernicus and


on to Isaac Newton. In order to complete his narrative, he found little need to travel very far from the narrow trail pointing always towards the supremacy of mathematical proof as the ultimate criterion of the new philosophy. His sources could always be located within the literary cannon of the science of astronomy, from the ancient Greeks through medieval scholiasts. Thus, if one were to search for some great cardinal moment on which to hang the idea of a great revolutionary change, one might find no better than the profound reorganization of the cosmos represented by the publication of the *De revolutionibus*, in 1543. Remaining within the boundaries of this internalist perspective, Thomas Kuhn found no difficulty in creating a model of astronomical revolution that could come close to completely discounting the existence of any event external to the classical literary cannon, such as the new star was certainly to be considered.

It is hard to see where an event like the arrival of the nova, no matter how spectacular in might have seemed at the time, would fit into this school of thought. After all, it is fair to say that the literary record engendered by the nova, for all its sense of urgency and the cogent analysis it engendered was not part of the classical canon of natural philosophical literature to which these historians had paid so much attention. The authors who saw and wrote about the nova were undoubtedly very familiar with that body of writing of which Koyré, Kuhn and others spoke (and to which some later made important contributions). But the new star produced no single, powerful challenge to the “venerable tradition” that governed the thoughts and practices of the natural philosophers of the day, certainly none like *De revolutionibus*. Its appearance did, however, cast much doubt upon the worth of that ages-old and still central natural philosophy. As I have pointed out, it was the catalyst for the creation of an entire body of literature in its own
right. The contents of those documents demonstrate that nova observers had, by 1572, come to accept the existence of serious flaws within the literary canon at the heart of their sciences, quite apart from those that concerned Copernicus. Nova literature also demonstrates that they had also acquired a well developed theoretical and practical knowledge of the new tools and techniques that would ultimately become part of the essential toolkit of the seventeenth-century practitioner of natural philosophy, a development not particularly visible in the more well known literature of the period.

By coincidence, J.L.E. Dreyer’s *Tycho Brahe; A Picture of Scientific Life and Work in the Sixteenth Century*, originally published in 1890, was reprinted not long after Kuhn’s *Copernican Revolution*, in 1963. Dreyer, the editor of Brahe’s fifteen volumes of surviving written material, had felt it necessary to include an entire chapter on his subject’s response to the new star, as well as further extended discussion of the study of the nova in later paragraphs and sections throughout the book. The author chose to write a broad biographical narrative of Tycho’s life, which included much information and discussion of the Danish astronomer’s age rather than an account limited only to the intellectual exercises that made up the sum of his lifelong research. While many later authors saw little relevance in this to the general debate of the origins of and influences upon seventeenth century natural philosophy, Dreyer must have felt compelled to recount at some length the events surrounding the arrival of the new star.

This was because for Tycho, it was clear to his biographer, the work of observing the nova was a powerful intellectual experience which informed the remainder of his long career. No researcher looking into the course of natural philosophical events in the late sixteenth century can overlook the work of Tycho Brahe. Dreyer understood that this
meant understanding the place of the nova in Tycho’s intellectual life. As old as this work now is, it thus remains the broadest and most detailed modern contribution to the subject of the astronomical events of 1572. Though one quickly finds that it has become dated for other reasons, because of this insight, it is an essential starting point for any nova research.

Dreyer’s inspiration is not hard to find. His other, far larger contribution to the history of science, his edition of Tycho Brahe; Opera omnia (abbreviated as TBOO), is a storehouse of original material on the new star. Within the fifteen volumes, all first published at the beginning of the twentieth century, one may find numerous letters to and from Tycho on the subject, his 1573 book Nova stella, and also his later, lengthy collection of observations, reports and publications about the nova: Astronomiae instauratae progymnasmata (this was the book published in 1602, shortly after Tycho’s death). All together these constitute our greatest single source of information on the star and its observers.

In addition to the Nova stella and the Progymnasmata, it is just as easy to uncover half a dozen other scholarly reports written within a year of the star’s first sighting. There are, to my knowledge, no modern studies of the contents of these works as individual studies or in relationship to each other. While Tycho certainly included edited sections of some of these works within his later compendium, he also chose to leave out much that, to later students, might well be of great value. Twentieth-century scholars have not been ignorant of the existence of, say, Heronimo Muñoz’s 1573 report of the new star: Libro del nuevo cometa (the title alone should spark a certain amount of curiosity: few astronomers today would mistake a nova for a “cometa”), yet little beyond a sentence or
two mentioned in passing has entered the modern historiography of the new star. Muñez has fared better than most.

So it seems that Hellman’s contemporaries, and may I add later students of these works, continued to display less interest in this aspect of the contents of books like the *Progymnasmata*. Adam Mosely, for example, who clearly had spent much time between the covers of Tycho’s collected volumes, chose instead to concentrate on the nature of Tycho’s epistolary connections in his *Bearing the Heavens* (1974). His excellent study produced much valuable analysis of the communications networks between members of the scientific community in Brahe’s day. Still, the author resorted to the traditional tactic found in most other studies of the science of the age when the nova is brought up: making mention of the new star in a short paragraph where appropriate, primarily to delineate the chronological boundaries of the author’s main focus. Examples of this approach abound. Although she was aware of Tycho’s compendium, Jean Moss in her well-documented study of the controversies set off by Copernicus’ *De revolutionibus* in the later-half of the sixteenth century, *Novelties in the Heavens* (1994), skipped over the entire subject. One is apt to find the omission especially curious in that her third chapter is entitled: “Evidence from the heavens.”

In part, this also may be seen as a response to more recent historiographical trends. If, in the post war decades, historians of science such as Thomas Kuhn and Edward Grant were concerned to create a narrative of change and continuity in the evolution of a science whose premises and central facts had been enshrined in literary and mathematical traditions dating back millennia, other writers, working as early as the 1930’s, had been

concentrating more upon describing the social structures, institutions and mechanisms which, in the early modern period, came to act as catalysts of intellectual and philosophical change.

This perspective has grown to become a central focus of current discussion, and it has produced its own arguments and conclusions. Of first importance here is the idea that, in contrast to earlier scholarly concerns, scientific endeavor needed to have a broader set of definitions than that of mathematical certitude, or for that matter, that there was any “single coherent cultural entity called ‘science’ in the seventeenth century to undergo revolutionary change,” rather, one might look at the natural philosophical milieu of the sixteenth and seventeenth centuries and see a “diverse set of cultural practices aimed at understanding, explaining, and controlling the natural world, each with different characteristics and each experiencing different modes of change.”9 As the author of these comments, Steven Shapin argues, perhaps the very idea of a single “Revolution” doesn’t make great sense in the first place.

Perhaps the most famous of the works to focus on this way of seeing science is Robert K. Merton’s *Science, Technology and Society in Seventeenth-Century England* (1938). There Merton outlined a mechanism by which the ideals and religious beliefs of Protestants in the seventeenth century played an essential role in creating a cultural and philosophical seed bed from which modern science might grow. More recent scholars have expanded upon premises of this thesis, focusing on what might be call an “externalist” perspective, in opposition to the internally driven mechanisms that Koyré and others focused upon.

Working to develop this perspective, recent scholarship has described what might be called the “sites of science,” looking into the interactions of those not narrowly defined as natural philosophers in the traditional sense. By way of example, William Eamon chose to examine the effects of public spaces and interactions in his article “Markets, Piazzas and Villages,” finding that the common places of exchange and interaction were also “repositories of empirical knowledge.” Eamon noted that the growing market economy of the West in the sixteenth and seventeenth centuries acted as a catalyst in creating a culture of collecting. A growing realization that nature was far more diverse that might be imagined, brought upon in part by growing the diversity of Europe’s expanding market economy forced heretofore scornful scholars and natural philosophers to take more interest in (and have more respect for) the knowledge held by farmers and husbandmen, village herbalists, and town craftsmen.

Court society, collection cabinets, popular publications, early scientific societies and academies have all undergone similar treatments. Paula Findlen, in her Possessing Nature (1994), has illuminated the way in which the collections of natural objects so popular among nobility and the wealthy helped to direct the study of nature and expand the modern historian’s definition of science and scientific endeavor. Bruce T. Moran has investigated the nature of European court life in the early modern period, seeing in the mechanisms and norms of political culture an alternative means of support for natural philosophers who wished to be independent from the continent’s system of universities.

Writers such as Anthony Grafton, who have been very respectful of the “culture of the book,” that is to say, the literary traditions of natural philosophy, have noted that in

the age of the nova, university scholars themselves began displaying more interest in what had previously been seen as the “lower,” intellectually suspect, not particularly well-organized knowledge of common people. From this perspective, it would not be hard to make connections between developments in military technology, to give one example, and the developments of a science of motion or between the knowledge of peasant herb gatherers, and the revolutionary medical theories of Paracelsus.

Again, as with the internalist perspective, one might see little room for analysis of the controversies the nova set into motion. In his *The Lord of Uraniborg: A Biography of Tycho Brahe* (1990), Victor Thoren concentrated his efforts on the study of a scientific career and life in the late sixteenth century. Thoren’s book is a detailed investigation of Brahe’s experiences and their effects upon the choices he made as a member of the Danish court and as a natural philosopher. Here, Tycho’s early life in particular was examined with the intent of connecting the young nobleman to both the Danish political elite and its traditions, and also to the new philosophical winds that were then blowing across Europe. Brahe is portrayed as the product of his unique upbringing among the Danish nobility, and also as someone inspired by intellectual revolutionaries like Paracelsus. Later, in his final chapters, Thoren devoted much effort to describing Brahe’s astronomical masterpiece: his home, workshop and observatory Uraniborg, describing its construction, its personnel, Tycho’s research program, his working relations with the citizens of the island upon which the observatory sat and other aspects of the scientific enterprise he built over his working life. Here the author was able to provide a more detailed and nuanced description of the astronomer’s society, work and life than had his predecessor, Dreyer, a century before.
In Thoren’s fourth chapter, entitled “The New Star,” the author chose to concentrate on describing Brahe’s reticence over publishing his *Stella nova*, the book which has provided us much evidence about the star’s effects on astronomers. Thoren described at length Tycho’s struggles with court opprobrium, with his colleagues’ encouragement, and finally the various subterfuges engaged to allow Brahe to publish his short book. This later biographer, however, dedicated only two pages to the actual work of the astronomer, giving the reader a cursory overview of its author’s nova observations and conclusions, with little analysis or context added. Throughout the chapter, other nova reports and correspondence are not specifically mentioned at all. Thoren’s “The New Star” includes a passage relating to Tycho’s relationship with his wife Kirsten Jørgensdatter and narrates events surrounding his friendship with paracelsan Johannes Pratensis and French Ambassador Charles D’Ancey. Concluding this chapter, the author suggests the value of the nova’s appearance to the young nobleman: (it) “forced him through a crisis of his young manhood and put him on the path he was to follow for the rest of his life.”\(^\text{12}\)

To whatever extent that this may have been true, or valuable to students of the subject, it certainly had little to add to our knowledge of the discussion of the nova itself, its effects on astronomers across Europe, and, in turn, their effects upon Tycho and his theories and ideas. The new star was not an institution or the career of an individual, nor was it an economic or political network, after all. It was literally, a point in time and place; one which we know caused natural philosophers, including Tycho and some of the most important astronomers of the age more that a little consternation and concern. While

there is no doubt that multitudes saw the new star, its greatest and most lasting intellectual effects would have been upon the very natural philosophers who modern historians have identified as making up the body of writers whose work constitutes the canon of the “Scientific Revolution,” importantly, the young Tycho, his colleagues and correspondents, Thoren did not include in his study.

For whatever value may be found in thinking about the natural philosophies of the sixteenth and seventeenth centuries in a particular way and from a particular set of perspectives, no matter how narrowly or how broadly defined, there are bound to be elements left out or minimalized in any narrative. The study of the new star of 1572 seems to have been left to its own devices on that account. True, the collection of its surviving artifacts is almost vanishingly small compared with the records, documents and historic sites that researchers sometimes have at hand. For whatever the reason may be, however, and despite the possibilities for investigation, little new insight has been offered to students of the nova since Hellman’s last publication. Most recent writers seem to have garnered their knowledge of the new star, and their perspective of its effects on the scientific debate of the day, from Hellman’s and Dreyer’s efforts. I would like to suggest here that even the very same personae that they do include in their discussions might have more to offer contemporary readers, and a review of contemporaneous events and technological and scientific developments surrounding the arrival of the new star in light of more recent research might prove a helpful addition to these contributions.

The mysterious new star, after all, had arrived at a very interesting time in the intellectual history of the West. The second half of the sixteenth century was not without its own broader controversies, intellectual, political and theological, which, there can be
no doubt, had their own profound effects upon the opinions and perspectives of the
Nova’s observers. In the decades before its appearance, the traditional corpus of
knowledge (and its authority) that has stood at the center of western society’s knowledge
of the world had come under assault. At the beginning of the century, the Church, which
had assured and comforted mankind with its authority and grandeur, had begun to split
into several warring factions, each with its phalanx of philosophers and theologians hard
at work contradicting and condemning each other. By the year 1572, thinkers on all sides
of the ongoing religious debate had been furiously throwing invective, scholarship, logic
and biblical authority at each other through the years of the age’s numerous religious
wars.¹³

That other ancient and ubiquitous source of authority, the one Nova observers
relied most upon: the heritage of classical knowledge, rediscovered and diligently
digested over the previous five hundred years, was facing similar challenges. Along with
Christianity, Greco-Roman natural philosophy, its intellectual tools and its body of
knowledge, stood as an essential foundation of western man’s sense of place and purpose.
But with the passage of time, the very knowledge so promised as truth began to seem
otherwise. As scholars continued to examine that classical inheritance, they increasingly
took note of contradictions, inaccuracies, omissions and downright fantasies.¹⁴ That great
chronographic achievement of the Roman Empire, the Julian calendar, was noticeably
(and embarrassingly) drifting, and was days and possibly even weeks off. It had not
boded well for the standing of ancient geographers that, at the end of the previous

¹³. Harold P. Nebelsick, The Renaissance, the Reformation and the Rise of Science (Edinburgh, UK: T & T
Clark, 1992).
century, European explorers accidentally stumbled upon an entire heretofore undiscovered continent, one that even the greatest, most respected ancient scholar, Aristotle himself, had no idea existed. That continent had landmasses, rivers, mountain ranges, species, races and civilizations that no European had ever seen.  

Newly invented devices that seemed to enhance man’s power could, it had become apparent, cause just as much disorder as good. Had it occurred to any one that printing copies of the Bible by the thousands allowed people, previously dependent upon religious authority, to read God’s word themselves and see in it what they might? The spread of the strategic weapon of the age, gun powder, had, by the year of the nova’s arrival, completely altered the balance of power among kings and their subjects, giving rise to more centralized states, far more expensive, vicious, and less personal wars, and an entire class of engineers, practical mathematicians who used their skills to further their patron’s political and theological goals.

But the intellectual tools and received wisdom of the ancients weren’t about to die a quick death just yet. They were still powerful. They were rational and reasonable. Aristotle, especially, had himself been an acute observer of nature and had insisted that all philosophers be so. He had constructed a framework upon which to categorize one’s observations: to put one’s experience of nature into a recognizable set of relations that could therefore make them understandable, make them useful. The great Philosopher thus assured us that we had indeed the ability to understand why things happened the way they did and what those explanations meant. This compelling message had helped to ensure

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that Aristotle’s works and his ideas had remained at the very center of European education, read and digested, discussed and argued about by every university student of the age of the nova, including our nova observers themselves.

Equally so, the second-century C.E. astronomer Claudius Ptolemy, who had by the sixteenth century garnered as much respect as had Aristotle, had built what must still be admired today as a mathematically complex and subtle, imminently useful model of the universe that in 1572 still held sway over the intellectual world that the nova’s observers inhabited.¹⁷ Almost as much as Ptolemy, the newly printed works of Archimedes, Plato and Apollonius had caught more than the causal attentions of literate, educated Europeans. All of the people whose thoughts about the nova that have survived to be read by us were intimately familiar with and powerfully influenced by these classical authors. More than any other part of the venerable tradition of ancient literature, these writers inspired the imaginations of those who looked into the sky to see the new star in the early winter of 1572.

If, in that year, much of this tradition and its epistemology were being undermined by recent events and discoveries, it still held pride of place for natural philosophers across the spectrum of the western intellectual endeavor. The nova’s observers had been reared within the bounds of its intellectual boarders. This they knew, but they were just as well aware of the great changes taking place around them that were shaking that tradition to its foundations; altering the geography of those very borders, so to speak. All these contradictory intellectual currents swirled around the astronomers and

natural philosophers that witnessed the new star’s arrival. To put the arrival of the new star in its proper historic place, the reader of Tycho’s and his colleague’s nova reports must also see the effects that these forces had on their perspectives and beliefs.

For the reader of this thesis, the events and ideas I have described above allow me to bring up another set of perspectives and concerns that can and should also be brought to bear on this discussion. These also center on our understanding of the nature of scientific change, and the centuries long evolution of the modern philosophy of science. They also act as a counterpoint to the historiographical comments I have made above and are therefore certainly worth discussing in the process of introducing the history of the nova as part of the history of astronomy in the post-Copernican half-century in which the new star appeared.

What is the nature of those perspectives and concerns? As preface to describing my research, I must start with the suggestion that the epistemological model found in Copernicus’s last and greatest work: *De revolutionibus orbis coelestrum*, for all its value to them, was not capable of providing his contemporaries with a satisfactory description of the heavens he had sought to explain. This was not solely because the canon had produced a complex and abstruse set of arguments, or that he postulated the wild and vaguely heretical idea that the Earth moved, but also because Copernicus, understanding his art to have stemmed from the classical tradition almost solely represented by Claudius Ptolemy’s *Almagest*, apparently did not see any need to employ the wider uses of mathematics and mathematical methods that during his professional lifetime were coming into maturity across the continent (uses he was certainly familiar with) and their
implications for the study of the heavens in his master work. These new tools had in the first decades of his century found their greatest applications in measuring the physical realm of the Earth, but had yet, until the arrival of the new star as it turns out, to prove their value in the direct examination of the cosmos Copernicus spent much of his life considering. They included the new trigonometric techniques I have mentioned above, developed by cartographers and geographers; methods that could be equally valuable in the study of the heavens. The new disciplines also included the art of vision; that is to say the art of seeing the world, not as a symbolic expression of God’s will through literary traditions, for instance, but with a dispassionate eye to record and measure what was actually before the viewer.

Neither the new mathematics, nor the new skills required of observation have a prominent place in *De revolutionibus*. Despite the fact that Copernicus was an adept astronomical observer himself, he seems to have missed the connotations of the arrival of the comet of 1533, an event that many of his contemporaries immediately understood to be an opportunity to disprove some of the very fundamental premises of both his and Ptolemy’s systems. These changing perspectives, to which he appears to have paid little attention, were part and parcel of the fluid and rapidly mutating natural philosophical debates of the age; they were the engines of discovery and understanding for a then expanding scientific community, and they were to become indispensable for the astronomer in 1572.

Much can be said about Copernicus’ broader intellectual and cultural life, and the struggles of his age, which lead us to feel that this theoretical - mathematical trail can by no means be followed in the relative isolation into which those examining the logic of the
De revolutionibus sometimes place it. How do these events of the later sixteenth century and works of nova contemporaries play into the model of scientific change that relies primarily upon the literary records of natural philosophers like Copernicus and later writers? They barely appear at all. The end of the fifteenth century saw the discovery of the new world, its age’s intellectuals reacted to the vast wealth of new plants and animals brought to them from around the planet. Scholars picked up the new tools of the visual artist: perspective as well as the prolonged and detailed study of nature found in the works of Albrecht Dürer, Benvenuto Cellini and Leonardo da Vinci, and widely disseminated them through the use of the printing press.\(^{18}\) Leonard Fuchs published the first original study of plant life since the end of the Roman Empire, the Historia stirpium, in the year before De revolutionibus, containing some five hundred original woodcut prints drawn from life. Cartographers like Gemma Frisius and Gerard Mercator built upon the foundations of ancient authority, using the reports of sailors to reinvent the mathematically based science of measuring and describing the Earth. Both men studied the heavens as much as they evinced active interest in the geographical structure of the earth; for all practical purposes, they made no distinction between the two when it came to figuring out how to record and understand what they saw.

Medicine found a new vision of man in Andreas Vesalius’ De humani corporis fabrica, published, like the De revolutionibus, in 1543. Vesalius, as with most doctors of the age, knew the heavens just as well as most astronomers, its sister science, astrology being essential for all medical practice of the day. He was almost assuredly intimately familiar with Paracelus’ theories of chemistry and medicine (Tycho Brahe certainly was:

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his friend and fellow nova observer Praetensis, was a leading practitioner of
Iatrochemistry). If it had not been so much before, the foundations of our modern
philosophy of science: observation, mensuration and recent mathematical innovations
like those taking place in the discipline of trigonometry, had certainly become invaluable
for all those interested in the new philosophy by that year.

Despite the impression often given by generations of historians of astronomy,
who discuss works such as the *Alphonsine Tables* and Puerbach’s *Theoricae novae
planetarum* of 1472, and theoretical mathematical constructs like equants and epicycles,
it is clearly the case that, just like the Earth, the heavens were the focus of constant
examination by a very diverse range of investigators that saw different purposes in their
enquiries than those of Copernicus. These two aspects of the age’s intellectual endeavors:
concentration on the nature of theoretical models on one hand, and the struggle with the
veritable avalanche of new data, terrestrial and celestial, on the other, may seem
contradictory (or of less relevance) to readers delving into the details of Copernicus’
theory of lunar motions, for example, but can be understood (and seen for their value) if
one were to extend these ideas and examine the evolving definition of “astronomy”
throughout the intervening centuries.

Here in the records of the broader natural philosophical endeavor, I feel, one may
find the key to understanding the intellectual effects of nova in the light of the age’s
scientific milieu. In his informative article on Cartography: “Images of Renaissance
Cosmology,”19 David Underwood counters the basis of this delineation of theoretical

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19. Denis E. Cosgrove, “Images of Renaissance Cosmology,” *History of Cartography* 3 (University of
boundaries by noting that Renaissance natural philosophers made little or no distinction between what we now call geography, cartography and astronomy. Rather, for the age’s investigators, these were logically lumped together under the heading of cosmology: the study of the order of the universe, which included the heavens and the Earth, with little to distinguish the abstract intellectual borders between one and the other. Underwood calls this collection of scientific foci, “a project of the Renaissance,” noting that in the middle years of the fifteenth century the more creative minds of that age began to develop the means to mathematically define the locations of cities, oceans and mountain ranges on the Earth’s surface, and simultaneously, use those same tools to understand the heavens and their relationship to our planet.

For the author, the foremost of these tools was the rapidly expanding practical application of trigonometry. While it is the case that ancient astronomers had some basic numeric tools at their disposal, and, in the centuries before Ptolemy had developed an elaborate system of geometric logic to buttress their theoretical constructs, the art and science of measuring great distances came into fruition at the beginning of the sixteenth century, just in time to make an essential contribution to cosmology.

The effects of these developments are hard to overestimate. At one level the subject of “Cosmology” became somewhat of a fad by the middle years of the sixteenth century. Rulers named their heirs in its honor (as is attested to by a long line of Medicis). Untold numbers of publications were given titles with the word “Cosmographia” ensconced, to the point at which publishers felt secure in changing the title of Claudius Ptolemy’s ancient work from “Geographica” to “Cosmographica.”20 The modern author

John Hale has written of the discipline that “for a time, in certain areas (of northern Europe) it seemed to assume the proportions of a “craze,” becoming an ostentatious part of the mental furniture of all educated men.”21 Another contemporary scholar has seen in the growth of the new subject of cosmology nothing less than a “reconceptualization of space based upon the new tools of mathematics, primarily trigonometry.”22

This construct only began to disintegrate into its daughter disciplines during the early decades of the seventeenth century, a victim, it would seem, of what a modern observer might call information overload. In the intervening decades, however, much about the investigation of the natural world had changed. That this investigation involved the study of all of its aspects in concert with each other was the central assumption of natural philosophy in the years before and after the De revolutionibus, it was more so in the year of the nova. For the scholars, craftsmen and investigators who are the central subject of this study, the events in the heavens, in particular the first nova in their recorded history, were part and parcel of the greater and more immediate, more intellectually profitable study of the entire world system, than that of Copernicus’s project: the restoration of the ancient mathematical discipline of predictive astronomy; a discipline that tradition had placed as far away from the study of the Earth as were the stars themselves.

Observation of nature in the West had begun in earnest long before the arrival of the nova. It became a central part of western culture in the Renaissance, an age which saw radical change in people’s understanding of all of the contents of universe, including themselves. The discipline of observation, its physical and intellectual tools: unbiased

vision, accurate recording and organization, its central role in the development of mensuration, the transference of its raw data into an often mathematically referenced model, form a path in the history of the development of astronomy that is at best tangential to the logic and reasoning of *De revolutionibus*. It made up an equally essential means of discovery and proof as did the theoretical mathematics at the heart of Copernicus’ book; observation in the sixteenth century, whether of a terrestrial nature or celestial, used the newest numerical techniques then available. The science of mathematics and the art of observation went hand in hand in the late sixteenth century in a way simply not visible in the Canon’s great work.

This is an important part of the argument I plan to make for the value of studying the response to the new star by scholars interested in the nature of astronomy in the period between the publication of *De revolutionibus* and the development of the telescope at the beginning of the seventeenth century. I hope to demonstrate that, just as much as had Copernicus’ great book, the appearance of the nova in 1572, a decidedly not theoretical astronomical phenomenon, caused intellectuals all over Europe to reconsider the very nature of the universe. Astronomers and philosophers might in their leisure time theorize and dicker amongst themselves about the earth moving around the Sun, but they were under great pressure professionally to come to some understanding about the new star above. This reconsideration of the nature of the heavens and Earth using the new tools and concepts described above was as an essential act in the creation of the new sciences of astronomy and physics as were the greatest achievements of the next generation of natural philosophers.

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My thesis is, therefore, also a study in that other, “cosmological,” path, and how the endeavor to see and measure the entire world intersected with the purely mathematical realm of Copernicus’ Euclidean celestial constructs, among the first such uses of observation in astronomy, possibly ever. The first successful adaptation of such observational ideas to astronomy, I suggest, was triggered by the appearance of the nova in the late fall of 1572, a troubling and widely discussed arrival, it was certainly one of the most important celestial events before the dawn of the age of the telescope.

Before discussing what observers saw and recorded in the fourteen months the nova shone, in the next chapter, I would like to describe the aspects of the science of the age that made the appearance of the nova so disconcerting and frightening and therefore important. Western philosophy had by then undergone and absorbed nearly two thousand years of intellectual development and understanding as to why the star could not actually be where it seemed to be. Why was this the case? There is much to be said about the medieval record of intellectual challenges to the classical heritage that had been rediscovered and digested in the twelfth and thirteenth centuries. Natural philosophers like Albertus Magnus, Rodger Bacon, Nicholas Oresme and many others did not hesitate to criticize and question just about every aspect of Greek science.  

More than one modern writer, however, has pointed out the curious but very easily detected lack of interest concerning the physical nature of the heavens beyond the Moon on the part of these and later scholars. As mathematicians and astronomers, nova observers, like their

predecessors in the fourteenth century and earlier, had no trouble pointing out the flaws in Aristotle’s theories of motion, or the nature of matter, for instance. But all of these educated and perceptive people seemed to be at a loss as to how to effectively explain a single star appearing in the night sky.

In chapter three, I will discuss a parallel path in the history of western intellectual development, that of the study of mathematical astronomy. For the same two thousand years that western intellectuals sought to understand the nature of the world using the set of logical and rational tools represented in the collected body of scientific literature I have briefly mentioned in the above paragraph, there existed an alternate, distinct, yet subtly intertwined tradition: that of geometric mathematics, which barely saw the light of day in natural philosophical circles beyond its uses in predictive astronomy. Since this tradition underwent a rapid evolution in the sixteenth century, and came into maturity as the essential tool of our nova’s cosmologists, I will quickly trace its history. I have found that this will also be a good place to describe the changes that had occurred in the physical study of nature in the century before the nova’s arrival. The nova came at a very particular time in the history of the birth of our modern science: in the later-half of the new star’s century, European intellectuals, craftsmen, political and military leaders, explorers and businessmen had more than ever become infatuated with the measurement of the physical aspects of the entire cosmos. Their perspectives, and the tools they imagined, built and used, would have an important effect upon how the star was received.

My next task is to describe that astronomical community as it existed at the time of the nova’s appearance, namely the lives and works of those who actually observed the nova, in order to help explain why they came to the conclusions that they did. It is also
important to examine the social give and take of the observers of the new star. How much credence did they give each other’s ideas and opinions, what made them give weight to, or ignore one person’s or another’s work? While it is certainly the case that we have a broad range of firsthand accounts which to examine, these constitute the tip of a very large iceberg, so to speak. The vast majority of those who made comment about the new star were never recorded their thoughts in any way that has survived to our age. Their voices however, can sometimes be heard reflected in the words of those we do have. How did they influence the works that have come down to modern students?

I will then spend the next two chapters examining the heart of the matter, the writings of those who commented upon the new star. The body of available material is relatively large, even if it covers the reporting of what modern readers may see as a relatively small group of people. It is intellectually diverse, coming from numerous sources whose fundamental world-views varied widely. Still, common ideas and perspectives do emerge. What do these, and those dissenting ideas and opinions we also have say about the age and its views of the world?

Reporting on the nova has two distinct aspects. The ideas and theories of many people were recorded in the immediate aftermath of its arrival. By the summer of 1573, while the nova still shone, half a dozen books by well known and respected authors (not to mention the scores of pamphlets and tracts by lesser figures) had passed hands across the continent. These bear multiple approaches to the study of the new star’s existence. They are often excitedly composed and hasty in their assertions, running from confident conclusions based upon sound mathematical analysis, to wild conjecture with no sound
logical premise, these often contained in the same few pages of a given chapter of a book written by one author.

A different tenor can be discerned in these compositions than in those that were written and collected in the years following the nova’s existence and in the decades after its immediate response had died down. What changed in that time? I would like to suggest here that, in the later years of the sixteenth century a real movement to develop a new, more intellectually sober science of observational astronomy grew to maturity. This movement, along with its most famous member, Tycho Brahe, developed a new criterion for what was to be considered serious observational analysis. It is none other than Tycho himself who has provided us with the heavily edited compendium *Astronomiae instauratae progymnasmata* (finally published thirty years after the nova came and went) that contains by far the largest part of our collected knowledge about the new star. Completed as it was, decades after the nova’s disappearance, it displays the intellectual prejudices and preferences that its compiler had evolved over the years of astronomical work that the nova had inspired. What he chose and chose not to include is just as illustrative of his own development as a natural philosopher as it is of the work of his fellow observers thirty years before. Despite the inherent limitations of Tycho’s editorial perspective, I feel it is safe to make the claim that the *Progymnasmata* gives us the best view into the events surrounding the nova’s arrival and eventual disappearance. As such it is an excellent counterpoint in the study of the age’s natural philosophical debates to the *De revolutionibus* of Copernicus: one the abstruse theorizing of a solitary figure reconsidering the structure of the entire universe, the other, a storehouse of dozens of
voices, compelled to confront a heretofore unimaginable and seemingly unexplainable event taking place in the heavens above them.

All of the works to which the nova gave birth have this property: they have commingled theories and intellectual means to come up with any number of interpretations of the star’s nature(s) and meaning(s). I have artificially divided these contents and themes into two thematic groups. One, found in Chapter Five, can be labeled the deductive means of understanding, which I regard as being, in the eyes of its practitioners, not so effective a means of coming to positive conclusions. The other is the observational-mathematical means, discussed in Chapter Six, which for all the limiting factors of the technologies of the age, seem to have been, ultimately, what our surviving authors all took to be as most meaningful, most useful, most true.

In my final chapter, I describe how the age’s natural philosophers combined the use of mathematics with their observational skills and the traditions of natural philosophy they had inherited to develop their own conclusions about the nature of the new star, and what this meant for their understanding of the heavens and of the world itself. Here, in these last chapters, is where the modern reader will find evidence of the rapid decline of an entire epistemological model—that of the Aristotelian idea of causation—and the existence of another: that of the value—for the age’s cosmologists, the primacy—of the mathematical analysis of all natural phenomena. In the evidence that these recorders of the nova’s life have left us can be found as equally an important “new beginning” to the science of astronomy as that of the publication of the De revolutionibus, twenty-nine years before.
Finally, it seems to me appropriate that, before I begin the next chapter, I present to the reader a collection of nova images. I believe that this is the best way to introduce the dramatic pictorial evidence the nova inspired. This will enable the reader to visualize what I have described in words throughout the text. By way of this introduction, I will illustrate how (in sometimes very beautiful ways) the nova resonated through the intellectual and artistic life of contemporary European society, and long after its disappearance left echoes of its existence, in much the same way as had that star which had exploded some ten thousand years before.

Fig. 1: Tycho Brahe’s original woodblock-print of the nova, from his 1573 *Nova Stella*. In comparison to other contemporary depictions I have reproduced on the following pages, Brahe’s illustration is minimal; even Cassiopeia, the constellation with which the nova was associated, is not depicted, as it is in virtually all other illustrations. Beyond listing the (Ptolemaic) names of the stars themselves, there are no coordinate or graph systems, nor is there the otherwise ubiquitous for the age “queen’s chair” illustration that would orient the viewer to what they were seeing.
Fig. 2: A page from Tycho Brahe’s *Astronomiae instauratae progymnasmata* of 1602, his collection of nova reports dating back some 30 years to their original composition, and edited by him in the 1590s. This particular illustration provides accurate stellar positions of the nova and its neighbors, data that was impossible to produce accurately in 1572.
Fig. 3: George Busch of Erfurt published an account of the nova in German, in 1573. In this wood block print, the nova is labeled a comet, and depicted with rays or a tail emanating from it, a phenomenon that was manifestly not present.
Tychonis Brahe
Astronomiae Inferioris Progymnasmata
Quorum haec
Prima pars
De Restitutione Motuum Solis et Lunae
Stellarum Move Inerrantium Tractat.
Et
Præterea de Admiranda
Nova Stella
Anno 1572. exortā luculentur a āgō.
Fig. 4: On the previous page: the title page of Tycho’s *Progymnasmata*, Here Brahe (or his publisher, since he was dead at the time of its publication) chose to add a more typical illustration of the constellation, including a child in the position of the nova. The bulk of the book’s several hundred pages is given over to the Danish astronomer’s own later analysis of the new star, and also, his often edited reproductions of his contemporaries’ reports. It is this book that provides us with the lion’s share of the written records its observers have left to us. It is however not the only one to have been written on the subject.

Fig. 5: (page 43) An illustration from a book written by Thaddeus Hagecius, physician to the Holy Roman Emperor Rudolph II. In the spring of 1574, in response to the concerns and fears that the nova had generated among the members of the Hapsburg court, he published the *Dialexis de novae et prius incognitae stella*. Though he was among the observers who quickly came to the radical conclusion that the new star was to be found beyond the Moon, and thus in the realm of the eternal and unchanging *quintesence*, he illustrated his book with a very traditional image, that of the queen on her throne. Like Tycho, his correspondent and fellow astronomer, the stellar numbering system he used ultimately came from the Ptolemaic *Almagest*, by then the 1400 year old compendium of mathematical astronomy with which all active astronomers in the age of the nova would have been very familiar.

Fig. 6: (page 44) This is yet a more complex illustration of the nova. Some 31 years after its appearance, Johann Bayer published the *Uranometria: omnium asterismorum continens schemata*..., from which this illustration is taken, in Augsburg. In this compendium of 51 copper plates, Bayer incorporated several innovations, among which was the naming of the stars based upon their relative luminosity, a system still in use today. In locating his approximately 1300 star positions (the most complete list then yet published), Bayer largely relied upon a manuscript of Tycho Brahe’s stellar coordinates that had been circulating since 1598. This made his work also the most accurate to date.

Several aspects of Bayer’s print in particular make it of interest. First, the nova’s very presence tells us that it remained in the collective astronomical memory decades after the star faded from view. The nature of the illustration is interesting in other ways: Bayer chose to place the nova within the traditional realm of the seated queen. Etched across the picture however, one may discern the lines of the great circles that modern astronomers had by then learned to inscribe across the sphere of the heavens in order to place a star with great accuracy upon a mathematical coordinate system. In this sense, that it incorporates both ways of denoting a star’s position, it beautifully illustrates both the old and the new sciences of astronomy that coexisted in the late sixteenth century. In the body of the catalog, Bayer wrote a brief description of the star’s appearance and decline, strongly reminiscent of the descriptions produced by its original observers decades before.

In the background one sees the outline of the milky-way galaxy, as yet not understood to be a vast body of individual stars. This discovery was to come just six years later with the implementation of the telescope as an astronomical tool by Galileo.
IMAGO CASSIOPEÆ.
The nova’s observers often interpreted its existence to have more than one distinct meaning. Almost every one of the authors for which we have an extended record of comments sought to understand the star’s message in terms of its astrological significance.

Fig. 7: (above) one of the more observationally experienced and mathematically inclined of Brahe’s colleagues, Cornelius Gemma, son of the famous cartographer Reiner Gemma Frisius, and like his father, professor of mathematics at the Louvain, illustrated the possibility that the nova was in some way similar to the star of Bethlehem, and therefore it had been placed where it was to announce the second coming of Christ. In the 1575 book that contained this print, *De natura characterismis divinis*, Gemma also reported to his colleagues that he was sure that the nova was not a comet, as others had believed, and
that it was not located below the Moon in the sub-lunar realm of the corruptible. Earlier, in 1573, as the nova still shone, Gemma was one of those who rushed to publish an account: *Stella perigrinae*. The rough-hewn wood block print reproduced below (Fig. 8) from that work shows him less concerned with millennial possibilities and more so with the basic mechanics of the nova’s location. As with the previous print, the illustrator has difficulty depicting the Milky Way galaxy.

![Fig. 8](image1.png)

Fig. 9: (above) Tycho published the almost obligatory prognostication the star’s appearance made incumbent upon on the working astronomers that had a professional stake in astrology (i.e., all of them) in his *Stella nova*. Like most who also wrote about the more (to us) scientific aspects of its appearance during the fourteen months that the nova shone, he spent more time on its astrological implications than anything else.
Fig. 10: Jean Goselin, librarian at the royal court in Paris, fell back upon classical mythology in describing the nova’s position and purpose. Here Cassiopeia’s husband and neighboring constellation Cepheus are portrayed in a unique position: he has otherwise always been drawn facing forward and seated. From Goselin’s *La declaration d’un comet*, published in December 1572.
Fig. 11: the nova as art, ensconced among the artistic images of the sky that dominated the visual symbolism of the age, from the 1748 “Observations of the Comet of 1748,” by Pieter Gabry at The Hague.
Chapter Two
A Short History of Immutability

We have already discussed the first heaven and its parts, the moving stars within it… and we have shown that they are ungenerated and indestructible.

Aristotle, *On the Heavens*\(^{26}\)

This then is the reason why all those everlasting and unwandering stars, divine living things which stay fixed by revolving without variation…came to be…in order that each of them come as close as possible to attaining perfection.

Plato, *Timaeus*\(^{27}\)

The arrival of a nova today, long after the birth of the science that so readily and adequately explains its existence, would probably cause little concern (but much delight) even within the most narrowly defined community of serious stellar physicists and astronomers. Remnants of some of the stars that have become novas like that of the one that appeared in 1572 are often easily discoverable by well-equipped amateur astronomers in their backyards.\(^{28}\) New stars have been known by modern scientists to have appeared in our skies in the distant past because Chinese, Korean and Japanese observers have been recording such stellar events for thousands of years. One may assess the western observational record in light of that produced by Asian astronomers who,

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unlike their European counterparts, seemed to have had no difficulty noting the arrival of “guest stars.” Surviving archives from these civilizations provide us with the history of more than three hundred sixty celestial phenomena in the two and a half millennia that they were kept. These include sightings in the heavens between the beginning of the thirteenth century and the nova of 1572 that would be hard to describe as anything but novas.29 Some of these, like that of the one appearing in 1264, are recorded as being plainly visible in daytime.

Given this long history, the awe and consternation caused by the 1572 nova among contemporary Europeans, therefore, might seem at first glance to be out of place. It is just the excitement that the new star did cause however, that makes its appearance so valuable to the study of astronomy in the late sixteenth century. Why that awe and consternation might be considered a reasonable response needs to be explained before I continue any further in discussing the response itself. Seen in the context of the natural philosophy of the time, the concern expressed by its observers was well justified. Here and in the next chapter I will describe that context: a two thousand year history of celestial theory and speculation, the first and greatest expressions of which, surviving the ages, came to rest firmly in the minds of Renaissance natural philosophers millennia after they were written down. In this chapter I will describe two of the paths traveled on that historical trail. In the next chapter I will take up a third, concurrent path, one which was equally as old, but radically different from the first two. All of these, it must be underlined, had been sewn together (rather imperfectly, it should be pointed out) to make up the central part of the intellectual tool kit of the sixteenth-century astronomer.

To end my discussion of the history of the heaven’s immutability that will make up the bulk of this chapter, I will describe the sixteenth century’s other, newly matured, broader tradition of natural observation: that field which the nova’s contemporaries called cosmography. This category included and combined such modern topical headings as geography and chorography as well as astronomy. The discipline of cosmography had its own founding fathers, ancient and modern, and its own distinctive logical constructs to guide its practitioners. If mid-sixteenth century cosmographers fully expected to be able to rely upon the works of the classical heritage I shall describe in this chapter to provide them with an understanding of events taking place in the skies above, they were also well aware that the new tools developed in the course of that age’s geographic explorations and mathematical advances offered potentially great dividends to their astronomical researches.

Dividing these intellectual traditions up as I do here is an artificial construct. Most of the observers I am interested in would have been quite comfortable working with the tools that all of these perspectives provided; dare I say more or less depending upon their own habits of thought and preferences. And this is not to even begin to consider the broader, less formally “academic” ways of understanding nature that informed professional scholars and non-university trained citizens alike. Much might be said about just what the later of these made of the nova, had more of their thoughts and ideas survived to our time. We are aware that below the surface presented us by the literary records of the age’s educated and political elites, an active world of natural study and observation thrived across the continent. The writings of Hermes Trismegistus and

30. Victoria Morse, “The Role of Maps in Medieval Society: Twelfth to Fourteenth Century,” History of Cartography, 3 (2007): 25. An important topic in its day, chorography was the science of describing a city or region in such a way that pointed out its unique aspects.
Paracelsus in their own way held great power over the imaginations of the new star’s contemporaries. At the very same time that nova watchers craned their necks to look up at the night sky, these observers of nature here on Earth were busy at their alembics mixing and distilling “elements,” struggling to find the alchemical keys to the secrets of mater. It is incorrect to say that professional astronomers like Tycho Brahe and Wilhelm IV were somehow “above” these concerns and interests, or not influenced by them. Nevertheless, the distinctions I draw here are valid. They serve their purpose: ultimately, as will be seen, for the nova observers I have found it was the changeless realm of the Aristotelian universe that most powerfully informed their astronomical views. It was Aristotle’s vision of the physical construct of the heavens, the one I shall describe here in this chapter, that came to its end in the late sixteenth and seventeenth centuries; it was the mathematical constructs first assembled by his classical contemporaries that survived the coming of the new star.

The model that Western science had by 1572 long relied upon to define its most basic assumptions about the physical nature of the celestial region beyond our world was to be found scattered among the written records of three sometimes opposing theoretical camps; all of which had their origin in classical antiquity. The most influential of these, for its immediate intellectual descendants as well as later generations, was the collected works of Aristotle. Aristotle’s elder contemporary and mentor Plato, however, can be considered to be the founder the first theoretical camp. He had been, in turn, the inheritor

of a tradition that made numbers and geometric shapes possessors of hidden meanings; values and qualities, and that these had been arranged by their creator in masked relationships. In the minds of many generations of his students, it was the primary goal of natural philosophers to discover these secret relationships; their only sure tools being those of our common intellects.

In his *Timaeus*, Plato wrote that the heavens were populated by intelligent beings—the stars and planets, deities themselves, whose motions reflected their desire for perfection, imitating the great world soul that was made for and animated the universe. The creator of that cosmos, at once a craftsman and an immortal deity, had as his central goal creating good. Being free of jealousy, said Plato, he wished the universe to resemble in every way possible the (moral) goodness he himself reflected. Bringing order out of disorder, he made the physical world as perfect as it could be—and that perfection was therefore reflected in the order of matter, space and time he created and made visible to man.\(^{33}\) The Universe therefore was the physical example of the craftsman’s desires. To observe his order—his *kosmos*—to discover its pattern, its geometric and numeric relations, was to see the wisdom and rightness of the creator. That wisdom and rightness, being perfect, were unchanging and eternal, like the stars, made to reflect those very qualities and ideas. For the author, the sense of sight allowed man to see the heavens, sense time, learn mathematics and thus be inspired to construct philosophy: “the cause and supreme good of this: the god invented sight and gave it to us in order that we might see the orbits of intelligence in the universe and apply them to the revolutions in our own understanding.”\(^{34}\)

\(^{33}\) Plato, *Timaeus*: 23, 36d-38b.

\(^{34}\) Ibid.: 47c.
One of the few texts to survive in the West after the collapse of the Roman Empire, albeit in fragments and corrupted copies, the *Timaeus* had a profound influence on the development of Christian philosophy and cosmology. Though its central cosmological ideas never grew into the mature, all encompassing rational system as had Aristotle’s, Plato’s alternative living world model stood in the wings, with its suggestive ideas. His intellectual descendants are found spread about the West’s surviving ancient and medieval literature, from Cicero’s *De republic*, and Lucretius’ *On the nature of Things*, to Augustine’s *City of God*, a founding work of medieval Christianity.\(^35\)

For this thesis, the most significant contribution of the *Timaeus* to the study of the history of natural philosophy is that of its perspective of the moral weight of the heavens. Being in a state of perfection (later to be seen as a mirror image of the Christian God’s wishes), the stars in their vault conveyed the lessons and moral instructions of the deity. The person who desired, therefore, to live the righteous and just life in accordance with the Father’s plan must glean his or her instructions, not solely from the revelations found in scriptures, but also from the unchanging celestial vision nightly presented to them. If one accepted these premises: that God’s order and plan for mankind could be seen in the stars, and that the church fathers had seen and interpreted and explained them correctly, then it was obvious that to question the nature of the heavens was to question the reasoning of the church fathers, and ultimately the church itself. Once Plato’s tale of creation became absorbed into the Christian tradition, doubting the accepted explanation of the celestial order became equivalent to questioning the rule of the Church.\(^36\)

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After the 1460s, when many of Plato’s other dialogs became accessible to scholars in Europe, it seems that few students of natural philosophy could resist mentioning platonic or neo-platonic ideas in their discussions of natural phenomena. Before continuing on to elucidate his overwhelmingly mathematical approach applied in the kinematic description of the heavens that made up the bulk of his De revolutionibus, Nicholas Copernicus sprinkled his introductory first book with numerous mentions of Pythagorean and Platonic figures and concepts: at one point calling the sun a “visible god;” a more Platonically colored phrase would be hard to pen.\(^{37}\)

The second camp, the most important for us, was based on the vast corpus of Aristotelian writing that had almost completely disappeared in Europe during the centuries after the collapse of the Roman Empire, and had came to light again in the Latin world during the course of the twelfth and thirteenth centuries. Colliding at that time with the equally powerful theologically driven world-view of medieval Christianity, it was digested, modified and woven into the fabric of European theology and philosophy. By the fourteenth century, the ancient Greek philosopher’s vision of the mundus, our universe, had become an essential part of educated Christianity’s understanding of God’s creation. Long after the discoveries, events and inventions of the fifteenth and sixteenth centuries had begun to force a reconsideration of European’s fundamental view of the world, Aristotelian physics remained an essential foundation of contemporary natural philosophy. It was by then understood by scholars and theologians to be an inseparable part of the fabric of the Lord’s creation, logically assimilated by using the very rational tools absent in the Old Testament and Gospels, but laid out in detail by the polytheistic

founders of natural philosophy. That any set of ideas and logical constructs could have
had the 2000 year run that the peripatetic school did have by the age of the nova may
seem to the modern reader an astounding feat. This is in part because its premises, its
logic and the knowledge it seemed to contain were powerful and effective tools in
themselves. It is also true that, as a body of scientific practice, the Aristotelian corpus was
flexible: its proponents, whether pagan, the Muslim and Jewish scholars who passed the
texts from one generation to the next, or Christian, found it adaptable to the cultural
norms of the societies that adopted it.\textsuperscript{38}

Because this vast collection of writings came to carry the greatest influence of any
surviving classical author among the educated elite of Europe in the centuries before the
arrival of new star, the young college student, the seasoned scholar, the doctor of
medicine, the theologian all made a chief concern of their intellectual life’s study of
nature the understanding of observable change in the world that was at the heart of
Aristotelian natural philosophy.\textsuperscript{39}

A dedicated observer of nature himself, he insisted that—in opposition to his tutor
Plato—the visible world around us was in fact what constituted the universe. Aristotle
endeavored to explain what he saw in nature by understanding its causes, the tools
leading to this understanding being deductive rather than mathematical. His universe was
understood through the logic of a physics of place and position in which, contrary to our
modern understanding, not all places were inherently the same. At the center of a finite
universe, he said, the Earth, the place of corruptible, alterable matter, was where change
occurred. Beyond the Moon, only circular motion, a rather limited form of change, took

\textsuperscript{38} Lindberg, “The Recovery and Assimilation of Greek and Islamic Science,” in \textit{The Beginnings of
\textsuperscript{39} Edward Grant, \textit{God and Reason in the Middle Ages} (Cambridge: Cambridge University Press, 2001).
What is for the modern student noticeably absent from his work is any need to explain the nature of the world using any mathematical tools or even numerical quantities.

That he seemed to have so successfully described an individual phenomena he came upon by explaining how and why it got there, what parts of it had changed and how, is key to understanding why millennia later, his methods became so valued by the scholars who rediscovered his work. Giving Aristotle’s intellectual tools and logical methods precedence over other ways of understanding nature, natural philosophers of the Middle Ages and later molded a very large part of their intellectual perspective to conform to the model of discovery, assimilation and understanding that they had absorbed from works like the *Organon*, and *De caelo*. With sound logic and good reason the Philosopher, they were sure, had explained the otherwise veiled workings of the heavens. Little surprise to see that, in later ages, intellectuals firmly believed that to suspect that his model was somehow flawed was to suspect reason itself, to doubt the power of rational thought.

So it became for natural philosophers in the centuries before the nova, that the two regions that together made up the universe were not in any way transposable. Within the realm of their terrestrial, sub-lunar world objects came into being, existed, or changed out of existence. Unlike the heavens, terrestrial matter changed shape, texture and color. Things were created, they altered form and they became corrupted. Animals were born, they lived and died. Wind blew, rain fell, and tides came and went.

Beyond the sphere of the Moon’s orbit, the boundary that contained this turbulent world, the sun and the stars moved about the central place of man’s existence in a way

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that appeared to be unchangeable and eternal. The stellar objects that astronomers observed seemed to never change their shapes or the paths they traveled. To be sure, common folklore throughout the ages held that change occurred in the heavens: the wandering stars—the planets—clearly moved in a fashion that almost defied explanation. Those who paid attention to that aspect of the natural world knew perfectly well that they had differing colors and grew and shrunk in the course of their orbits. But as far as anyone knew, they had always been there, and had moved in what had been, in some manner, a predictable pattern. The stars beyond the planets changed even less. Up beyond the moon, there was an order unknown on earth: the celestial world was smoothly and calmly silent, it seemed to all to be hearteningly rational, predictable, unchanging, eternal, “immortal and divine.”

Two interconnected ideas grew from these observations. The first was that, according to the reasoning enshrined in the Aristotelian corpus, since nothing changed in the supra-lunar world, it must be made of something distinctly different from things here on earth. Matter below the Moon changed because it was made up of a combination of the four elements that he postulated made up all things on Earth. Change the ratio or the makeup of these elements, and the object so constructed somehow changed. In the celestial world, there was only one element, called the aether, or the quintessence (fifth element). Since it was not made of any combinations of materials, it was complete, in its final form and therefore, while aspects such as the density of its accretion might alter, its fundamental nature would not.

The second idea was that, since celestial objects moved with a regularity unheard of on earth, and they seemed never to stop, their motion must be in the pattern of an

41. Ibid.: 463.
unending, and therefore perfect, shape: that of the sphere. For any scholar who delved into the secrets of the universe, the geometry of stellar motion became tied not only to the claims of Aristotelian immutability, but to the deified mathematical perfection of Plato, who had made the star’s motive force an active intelligence. For later generations of natural philosophers who studied the Platonic tradition, an unavoidable conclusion was that the heavens were populated by living beings just as eternal, and un-corruptible, clues given to man hinting at the greater perfection of the creator’s divine omniscience.

Taken as a whole, these pagan—turned—Christian constructs came close to providing a genuinely satisfying explanation of how and why the universe worked as it did. They gave man a central place in its workings and its purposes. The entire system did not fit together seamlessly; as it stood in the centuries before the nova, it could only be grasped in its totality by the efforts of the most learned men, who had dedicated their lives to its understanding. But each part did fit into the whole (or at least didn’t flatly negate each other), so that one aspect of the model could buttress another, which in turn propped up the next. So it was that the shape of the universe helped to explain God’s purposes for man just as had describing the nature of plant growth helped him understand the nature of his soul.

Challenged himself by still other phenomena that might, in contradiction to his theories, be taking place beyond the Moon, Aristotle took up an entirely new topic in theorizing apart from his ideas about the heavens: that of meteorology; “things above,” to explain how phenomena like comets and that faintly glowing band of light we call the Milky Way, both undeniably above us and far away, were in fact caused by atmospheric
effects and existed in the realm of the changing and temporal. In his “Meteorologica,” he described comets as products of gaseous exhalations of the Earth, heated to incandescence by the motions of the stars directly above them in the trans-lunar realm. They were made of corruptible material, so had ephemeral lives; hence their appearance and disappearance over time. To disprove the theories of his predecessors Anaxagoras and Democritus (whom he quoted at length at the beginning of the "Meteorologica"), Aristotle pointed out that comets traveled above and below the zodiac and therefore could not be planets, which were known to stay within that band of stars. The conjunctions of planets and stars were not their cause, as conjunctions occurred all the time, but not comets, which after fading did not leave stars. Stars, unlike comets, had no tails.

What we call the Milky Way galaxy likewise existed below the sphere of the Moon, but consisted of material that was incorruptible, or at least unchanging. That hazy band, it seemed to him, was the result of the pooling of this loose material by the influence of the movements of the Sun and planets (and not the result of Phaethon stealing his father’s chariot and scorching the universe). Such a straight-forward theory was bound to have its adherents; it was oft repeated by authors like Seneca, writing in the first century C. E., and seems not to have been seriously disputed in the centuries before the decline of classical civilization.

Aristotle’s cometary theory, as with its stellar and terrestrial equivalents, came to be a central construct of the European canon of scientific thought about events in the

heavens and became the major explanatory system available to natural philosophers until the age of the new star. As such, casual observers of the skies (which would have been just about everyone before the advent of the electric light) were quick to label anything new and seeming to be in the firmament a comet. The word itself had by the sixteenth century taken on a rather poorly defined set of meanings.

With a clear set of theories at hand that reasonably categorized and explained what they saw, observers were free to adduce all sorts of messages, warnings, predictions, tragedies, wars and plagues which the comet’s appearance must portend. Their fiery tails became common political symbols and had a century’s long run in the arts; from the Bayeux tapestry of the eleventh century, to the innumerable fifteenth and sixteenth century wood block prints which they regularly adorned.\footnote{Sara J. Schechner, “Monsters and the Messiah” in \textit{Comets, Popular Culture, and the Birth of Modern Cosmology} (Princeton, New Jersey: Princeton University Press, 1997): 78.}

No European recorder of celestial events I have read seemed to find in their arrival anything threatening to the traditional understanding of the physical nature of the heavens until after the beginning of the sixteenth century. Then astronomers began to look at them with a more critical eye. If the strange objects retained their mystery and astrological import for most, some natural philosophers began to question their location within the Aristotelian cosmos. Though the importance of this change in perspective will become clear in a later chapter, for now I should point out that the arrival of the comets of 1532 and 1551 engendered different set of responses than had previous cometary sightings. Both were attended to by observers using cross staffs, astrolabes and other observational tools in an attempt to determine their exact locations. Despite these efforts, in 1532 and again in 1551, no conclusions were reached by any astronomer we are aware
of that contradicted in any way Aristotle’s ideas about their origins and natures. The two comets each were determined to have resided below the sphere of the Moon.\footnote{Hellman, “The Role of Measurement in the Downfall of a System: Some Examples from Sixteenth Century Comet and Nova Observations,” \textit{Vistas in Astronomy}, 9 (1967): 44.}

For modern readers looking over the surviving works of ancient astronomical, medical, architectural and mathematical authors, the pronounced absence of curiosity about the physical nature of the stars seems to make more sense in this light. A large descriptive textual tradition exists as evidence that writers across the centuries of the classical age took great interest in nature and its secrets. Yet what stars were, “where they came from,” what they did, seem to be topics that were almost manditorially ignored or brushed aside. A brief glance at popular Greco-Roman works that have come down to us indicates the level of dis-concern that the author and educator felt appropriate for their students to assume, as well as how much seems to have been accepted as “well enough known” about the subject.

Much was written in the ancient world about the nature of the zodiac, motions of the planets, how far away the Sun and Moon were, how big the Earth was (and what its shape might be), mostly as a product of the distillation of the writings of Hellenistic philosophers. Some was intended for educated public consumption. By far the most famous of the classical world, and therefore the most copied, was Aratus’ \textit{Phaenomena}, a standard of didactic poetry, meant to educate the casually curious common (educated) reader in a pleasant, efficient and not too challenging fashion. Aratus’ central concern was to provide his reader with a useful guide to the heavens visible contents and their uses and effects here on earth. The constellations functioned as a calendar and clock (much as is Hesiod’s \textit{Works and Days}), delineating the seasons. The moon, the stars and
sun all exerted individual forces upon terrestrial life, the properties of which the author went into some detail in describing. What made them differ in their being that gave them these individual powers, however, seems to have been irrelevant to Aratus’ chain of reasoning. No mention was made of the star’s ages, makeup, physical shape or origin.

Manilius’ *Astronomia* would have been almost universally read by more serious students of the heavens after its publication in the first century B.C.E. Its central focus was the description of the heavens, yet when it came to the stars themselves, what they might be and where they came from, Manilius goes only so far as to say: “No different heaven did our fathers see, no different heaven will our posterity behold.”47 Four hundred years of experience seems to have had little effect on the opinions of ancient philosophers; Aristotle’s and Plato’s immutable and timeless realm had not and would not ever be the scene of generation and corruption, whatever its messages might be, they would be the same for future generations as they had been for those of the distant past.

Authors such as Aratus and Manilius, though writing for the non-scholarly reader, nevertheless remained very popular and came to be the bearers of the most respected and accepted opinions of their age and those following. As such, their ideas were bound to find their way into the volumes of the Roman Empire’s master compiler and recorder, Pliny the Elder. Interested in gathering what for him must have been “hard facts,” he filled some 24 volumes of information (and tales, fictions and rumors) about the entire world around him, as he understood it to be. Writing in the first century C.E., Pliny derived his understanding of the cosmos from this already well-developed tradition. Not willing to scrimp when it came to the consumption of papyrus, he filled almost an entire (modern day) volume on cosmology alone. Yet here he spent all of two short sentences

describing the physical contents of the heavens—vaguely filling the space above the moon with light; a light (he used the word: “stella e,” stars) that could sometimes appear on the masts of ships or the tips of soldier’s spears. What this phenomenon might have been seems to have held little interest; he concluded: “these things admit of no certain explanation; they are hidden away in the grandeur of nature.” Again, as had Manilius, Pliny seemed perfectly willing to follow tradition rather than subject his reader to even the slightest hint of personal speculation. Nature’s grandeur was as it always had been: mysterious, its secrets hidden from the direct observation of man here on earth.

Pliny in turn, became a primary source of encyclopedic information for writers such as Martianus Capella and Macrobius, two Latin writers of the fifth-century C.E. whose works: respectively *The Marriage of Philosophy and Mercury*; and *The Commentary on The Dream of Scipio*, survived the collapse of the Empire and came to be standard works of general knowledge through the eleventh and twelfth centuries. If Pliny had neglected to delve more actively into the nature of the stars, Martianus Capella and Macrobius, spent even less time in the realm of the celestial sphere.

These three writers’ works constitute practically all that the West understood concerning the classical tradition of knowledge about the nature of the heavens until Aristotle’s works were reintroduced in the twelfth century. For the educated and the scholarly of the Middle Ages, this descriptive literary tradition came to delineate the boundaries of all the knowledge that was valuable in the eyes of the age’s most influential thinkers and authorities, and therefore all that was needed to be known about the world around them. The tradition represented in these works informed readers not just

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about what was important to know, but what were valid questions to ask about the world, and how to discover the correct answers.

In the four centuries between the western recovery of the Aristotelian corpus and the arrival of the new star, students of astronomy not only took what physical theory they needed to understand the heavens from the works I have described above, they took their reasoning and argumentative logic, and the set of scientific priorities that guided their curiosity, their endeavors, and their fundamental beliefs. Like their Hellenic ancestors therefore, they relied upon the tools of logic to explain the mysteries of nature they found around them. Despite Aristotle’s dictums to the contrary, medieval scholarship relied primarily upon literary and purely rational tools to come to conclusions about natural phenomena. For university trained scholars, who had spent years absorbing the ideas and methods of the Philosopher, man could learn about nature first from time-honored authority, then, when concerned with previously unexplained phenomena, he could turn to debate, discussion and rational analysis to extend what was to be understood about the things he saw around himself. Complete understanding of the world would come when one understood the causes of objects’ existences and of natural phenomena.

The recovery in the West of the Aristotelian corpus of natural philosophy in those years did not recreate the entire science of astronomy from whole cloth. As I have mentioned, the works of Pliney, Macrobius and Martianus Capella, as well as parts of Plato’s *Timaeus* had all survived the centuries before Gerard of Cremona reintroduced the *De caelo* and *Meteorologica* to astronomers. Rediscovery of Aristotle’s works nevertheless startled and excited contemporary scholars.
Those who had access to these newly translated works almost immediately began to digest and interpret them, and publish their own versions of their contents. One of the earliest, most famous and long lasting was a brief description of the heavens: *De sphaera*, written by Johannes Sacrobosco, sometime in the 1230’s. Immensely popular, its twenty seven pages were still standard reading on the subject at the end of the sixteenth century; it was heavily commented upon by such authors as the Jesuit mathematician Christophe Clavius, whose 1581 commentary ran to over six hundred pages.

The thirteenth-century monk’s words confirm his understanding and appreciation of the Aristotelian traditions. They helped to give those traditions life for another four hundred years. For him, the universe was as the ancients had described, spherical in shape, finite, and divided by 10 circles, which the author took great care to describe in detail, starting with the celestial equator and ecliptic. Of the elemental nature of the heavens and its contents, Sacrobosco noted with succinctness: “Around the elementary region revolves with continuous and circular motion the ethereal which is lucid and immune from all variation in its immutable essence. And it is called the fifth element by philosophers.”

Less had changed in the literature of cosmology in one thousand years than had changed in the heavens themselves.

Before the end of the century in which Sacrobosco wrote, Aristotle’s works had been fought over at Europe’s most influential universities, banned in Paris (in 1210), readmitted to the schools’ curriculum, and absorbed into the canon of Christian cosmology, most famously by Thomas Aquinas in his *Summa theologica*, and finally condemned outright in 1277. This last, most encompassing judgment, only seemed to

promote the spread of the Philosopher’s ideas and also, to embed them even further into the minds of Western intellectuals. Just as had classical authors since the fourth century B.C.E., Aquinas co-opted Aristotle’s physical model of the celestial and terrestrial regions with no discernable alteration, using essentially identical language: “It is therefore clear that the material of the heavens is, by its intrinsic nature, not susceptible to generation and corruption, since it is the primary sort of alterable body and closest in its nature to those bodies which are intrinsically changeless…Motion is the only sort of change they experience…”\textsuperscript{50} he noted. That such a perceptive an original thinker as Aquinas seems so readily to have accepted celestial immutability is a measure of the idea’s resonance among the most well read and well educated minds of the age.

Though once again banned from university intellectual life along with many of his ideas after Aquinas’ death, in 1274, the Aristotelian construct of unchanging celestial spheres nevertheless remained an essential part of scientific and literary expression. It was the foundation of the stage upon which Dante Alighieri set his Divine Comedy. Several works of Dante, the exile and poet, are today noted for the striking celestial themes and metaphors they contain. The Florentine’s \textit{Convivio} (often translated as “The Banquet”) portrays a celestial region alive with intelligent beings as the stars; Dante’s Beatrice herself playing the role of Venus.\textsuperscript{51} His later work, \textit{Vita nuova}, displays an equally detailed understanding, and acceptance of, the ancient and venerated, spherical, homocentric universe, confirms a life-long commitment to the acceptance of its reality, and ultimately, the divine message which must lie within.\textsuperscript{52} These two works especially

\textsuperscript{50} Thomas Aquinas, \textit{Commentaria in libros aristotelis de caelo et mundo in Sancti Thomae Aquinatis}, \textit{Opera omnia} III: 24.
\textsuperscript{52} Dante Alighieri, \textit{Vita nuova}, 2: 1–2.
illuminate his broad understanding of the astronomical theory of his age. Far outdoing these in scope and detail, Dante’s *Paradiso*, the third and culminating part of his *Divine Comedy*, is set in nothing less than an accurate and detailed model of the Ptolemaic universe which his age had come to accept through the authority of Thomas Aquinas and his contemporaries. For educated Europeans, the physical nature of the universe above the moon had become so well an understood and, I suggest, a familiar enough region that poets and authors could build constructs they assumed their readers would find both recognizable and believable.

This is not to say that medieval intellectuals were in any way credulous innocents when it came to rigorous criticism of the classical inheritance of natural philosophy; this is demonstrably not the case. As the Aristotelian corpus of natural philosophy passed into the hands of scholars across Europe, they wasted no time dissecting it, discovering its weaknesses, and criticizing perceived faults. As might be expected from such a large and all encompassing body of theory, trouble could not be far off. For all their criticisms however, no medieval commentator I have read took any issue with the Aristotelian conception of the changeless heavens. Made of crystalline spheres of aether, driven by some divine motive force (or some form of intelligences; a derivative of the platonic notion that they were intelligent beings), the stars in the sky were changeless, eternal and even possibly somehow divine.

The *Livre du ciel et du monde* of Nicholas Oresme, the fourteenth-century natural philosopher and extensive commentator on the *Physics*, *De caelo* and other works provide the modern student with ample evidence of this acceptance among authors and readers who were more concerned with rational understanding than poetic import.
Oresme was a perceptive mathematician who developed well thought out models of such phenomena as the distortion of stellar light by atmospheric refraction.\textsuperscript{53} He was not shy about finding fault in Aristotle’s theories of motion, yet he seems to have acquiesced without question to the accepted classical model of stellar physics. Trained in the seven arts at the University of Paris in the middle years of the fourteenth century, Oresme found the time to write extensively and creatively on the nature of the world in his positions both as scholar at the University of Paris, in the 1340’s, as Archdeacon of Bayeux in the 1360’s and still later on, as an advisor to the French king Charles V. As well, because he was a student and long time associate of Jean Buridan and other mathematically adept thinkers of the previous generation, we may consider his extensive works to be largely representative of the most challenging and intellectually rigorous astronomical and mathematical thought of the age.\textsuperscript{54}

Oresme’s \textit{Livre} reveals the workings of a strikingly perceptive mind, displaying a perspective that, says one of his modern biographers, took a “strongly skeptical turn...tempered with his rationalism and naturalism.”\textsuperscript{55} He was a pioneer in the age’s efforts to find a way to mathematize the natural motion he observed around him in nature, developing Thomas Bradwardine’s ideas about quantitative relationships and ratios as measures of motion and time. The \textit{Livre} contains discussions about such phenomena as the center of gravity of the universe and the impetus theory, a means by which motion can be explained that is similar to our modern idea of inertia.

\textsuperscript{53} Nicolas Oresme, \textit{De visione stellarum} (Boston: Brill, 2007).
\textsuperscript{55} Marshal Claggett, “Nicholas Oresme,” DSB, 10 (1971): 223.
The Deacon was among the first to describe the universe as a sort of giant celestial clockwork, moved not by spirits or intelligences (as Plato or the neo-Platonists might have), but set in motion by God, and left to move on its own in a frictionless void. That void, however, was the heaven of the ancients: “(the supra-lunar world) cannot have been either generated or corrupted or increased or diminished or changed” he noted, concluding that its motions, regardless of their causes, were perfectly circular, eternal and unchanging. For Oresme, his talents certainly allowing him to imagine his own alternate physics of the universe, there was nevertheless something reasonable, some rationality to the idea of an unchanging celestial order which he along with his contemporaries, seemed unwilling to surrender.

Renaissance humanists of the following century, who criticized their medieval predecessors’ reliance upon what they perceived to be flawed texts and translations (interestingly, they were inclined to see scholars such as Nicholas Oresme as a medieval predecessor), assigned themselves the task of renovating the literature of astronomy and restoring it to its original classical accuracy and utility. For all the literary and philological talents of the best minds of the fifteenth century, however, none I have found mustered much more curiosity about the nature of stars as had anyone else in previous generations. To be sure, in the collective minds of the likes of Nicholas of Cusa, Cardinal Besarion, George Peurbach, Johannes Regiomontanus and Fra Domenico Maria Novara, these often considered to be the century’s greatest astronomical reformers, much about astronomy needed restoration. Most importantly for them, observers had for along time

suspected that some theoretical or literary error or errors had crept into the logic of the system some time in that dark interim between the age of Ptolemy and their own. Whatever these might be, they had thrown the system off its true bearings, and had made it impossible for the astronomers of their day to accurately predict eclipses and other celestial phenomena, or to deduce the length of the year, shortcomings that particularly upset their sensibilities.  

Suspicious at what they had perceived as the corruption of both the science and the literature upon which its practice was based, these and other fifteenth-century scholars worked to produce more accurate texts of their inherited corpus. In the course of their project to revivify the science of astronomy, they translated recently (for them) discovered Greek manuscripts of the great Alexandrian Claudius Ptolemy’s works, and began what was to become a multigenerational project of making more accurate observations of the movements of the heavens.

Early in that century, western Europeans were presented their first copies of the *Geographia*. This discovery of Ptolemy’s cartographic study and companion to the well known *Almagest*—a mathematically based study of the motions of the planets and stars that was central to the study of astronomy in the centuries leading up to the nova—set in motion its own conceptual revolution and renovation of the study of the physical nature of the earth. Among its many virtues, the *Geographia* described several methods by which cartographers might accurately place locations such as cities and land masses on maps, using mathematically determined positioning systems. The key to the most

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accurate of the several strategies described by the Alexandrian was a geometrically based understanding of the star’s positions in the heavens. Before the work’s rediscovery, western European maps looked more like paintings than products of a science of cartography. They contained images of cities and their major buildings, castles, rivers and images of saints, with no sense of geometric proportion that of necessity reflected geophysical reality. By the beginning of the sixteenth century, the lessons in geographic metrology that Ptolemy had taught had sunk in among the practitioners of the trade. Cities, fortresses and towns now became points on grid systems that allowed their makers to accurately place them on a realistic model of the Earth. For the students of the mathematics and physics of the heavens, The Geography gave natural philosophers an important insight: perhaps, it was realized, the means of coming to terms with the understanding the heavens might very well parallel the task of defining the Earth itself.  

By the 1470s the humanist’s long efforts at purifying a corrupt body of astronomical knowledge also began to bear fruit: the most important result of these efforts came in the form of George Peurbach’s rewriting of the medieval classic Theoricae planetarum—the Theoricae novae planetarum, completed and published a decade after Peurbach’s death by his student Johannes Regiomontanus, in 1474. The work became an instant success and an academic standard, one of the first astronomical books printed, and among the most published astronomical texts of the following century. Its authors described the universe as had Ptolemy in the Almagest (more of which in the next chapter). The Novae planetarum’s authors eliminated much of Ptolemy’s detailed mathematical analysis, presenting to their readers a comprehensive and practical

description of the workings of the celestial world that became the essential text of the age. Its central thesis varied not a whit from that of Aristotle’s however: the universe of the late fifteenth century, restored by humanist scholars to its pristine state, was the universe of purely circular motions and unchanging, everlasting stars.

As well as contributing his energy to getting the *Novae planetarum* published, Regiomontanus was perhaps best appreciated by professional astronomers working in 1572 for his *De triangulis omnimodis libri quinque*, first published long after his death, in 1533.\(^1\) This short work was a technical treatise that dealt at length with methods of discovering the distance of celestial objects using a geometrical technique known as parallax. In the next chapter, it will become apparent that most serious astronomers of the age were well versed in this late publication of the fifteenth century astronomical reformer. The techniques described in the *De triangulis* were the primary tools used by observers working to determine the positions of the comets of 1532 and 1551. *De Triangulis omnimodis* was also very much on the minds of those who decades later, saw the new star.

As important as the contributions of all of these texts were in their own way, they posed no threat to the hallowed traditions of geometry and the physics of astronomy that had by then informed educated people’s perceptions of the world they lived in for some two thousand years. For the most creative and perceptive minds of that age, classical tradition, despite many recent assaults upon its authority, still held out the greatest possibility of true understanding. According to Peurbach and his famous colleague and

student, the heavens were as Aristotle had said they were, made of crystalline spheres, and by implication, and a pronounced silence on the matter, changeless and immutable.  

For all the gravitas that fifteenth-century reformers could muster in the presence of their literarily and philosophically inclined colleagues, the very same scholarly community, as well as their less educated, but no less curious, neighbors about the growing towns and cities of the Western world in the early sixteenth century, might just as well look for understanding and answers among the pages of the quickly expanding popular press, which seems to have been perfectly willing to supply the needs of a growing and increasingly inquisitive population with by and large the same set of intellectual concepts and propositions as had Aristotle and Plato themselves.

Examples of the spread of classical authority beyond the walls of the university and court as the century progressed abound. Hartman Schedel’s Liber chronicorum (1493), also called the “Nuremburg Chronicles,” provided its readers with a detailed pictorial guide to the universe’s creation; Schedel’s universe was an orderly and well understood cosmos, the central human acts that make up the history of its denizens mark the passage of an ordained time. The first and greatest of these acts are illustrated in the seven wood block prints illustrating the creation of the world itself—one block for each day. In this series, God’s hand can be seen (literally) creating, one after the other, the spheres of a proper Ptolemaic universe. Of his stars in their heavenly eighth sphere: “on the second day innumerable … seemed to shine and radiate, however their lights are not solid (they twinkle?); they will not be overcome.”

Schedel’s book was decidedly for popular consumption. Today, with its artful prints and vast collections of data, it would make a fine coffee table edition. Still it is fair to imagine that, had there been any question about or curiosity concerning the physical nature of the heavens among the better educated of the bourgeois townsmen to whom he hoped to market his work, its editor would have not been too stretched to include more than one somewhat vague sentence in all of the works’ several hundred pages.

Fig. 12: The hand of God creating an Aristotelian universe. From the first chapter of the 1493 “Nuremberg Chronicles,” edited by Hartman Schedel.

For the general European reader little had changed by the middle of the next century, when Robert Record published the Castle of Knowledge, in 1558. Record gave non-Latin reading (i.e.: the vast majority of) Anglophones a well-ordered tour of the knowledge enshrined in the seven liberal arts that made up the basis of formal education since the creation of the university system some four hundred years before. Literally, from page one; the universe is described, true to all tradition, as a Kosmos, a Mundus in the grand tradition of Aristotle. For Record, man’s realm was the realm of the corruptible
elements: “which daily increase and decrease in some parts of them and are subject to continual corruption, they are distinct from the rest of the world, which has no alteration or corruption.” Clearly this order has been ordained by the master craftsman who has put each element into its place, such majesty must reflect the intelligence, desires and will of the divine creator: “that all those stars which be in the firmament do stand and continue in one form of distance each from another and change not their places in the sphere...(or as Aratus sayth) they be drawn with their heaven...yet they keep their places in the sphere.” For the citizen of the mid-sixteenth century, the universe above, if not so much the world of man below, could be made understandable, predictable, a comforting sign of God, evidence of the creators intentions for man, struggling here on earth.

Perhaps the most important legacy of Renaissance scholars’ efforts at astronomical understanding and reform came not in their reexamination of the classical cannon or in its interpretation in the light shed by Christian theology, but in the form of their own intellectual offspring. Both Peurbach and Regiomontanus produced students across Europe. Regiomontanus trained the wealthy Nuremburger Bernard Walther, who kept his papers after his death, preserved his work on trigonometry and published his own study of Euclidean surveying techniques in 1513. Peurbach’s student was also proclaimed by Fra Domenicus Maria de Novaria, an astronomer who taught a wide range of subjects at the University of Padua at the beginning of the sixteenth century, to have

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65. Ibid., 9.
been his own intellectual father. Novaria’s most inspired student and assistant was Nicholas Copernicus.

Universally understood to have been one of the great mathematicians of the age, Copernicus must also be recognized for his connections to the Renaissance humanists and their project: that of the resurrection of a pure and uncorrupted classical culture in all its forms. A translator of Greek poetry, doctor of medicine, church lawyer, author of a monograph on currency valuation; the Canon’s life and work beyond his astronomical study is perhaps the best evidence one can exhibit as proof that the man who could write a treatise on trigonometry and redesign the geometry of the universe, could also be deeply in tune with the ancient literary and aesthetic traditions with which his age was so enthralled. For the natural philosophers who gazed at the mysterious new star in the winter and spring of 1572 and 1573, no rigid intellectual boundary existed between the Aristotelian epistemology of science and the mathematically based perspective of natural philosophy that made up the final third of the classical traditions and to which I now turn.
Fig. 13: The world as seen by readers of Sacrobosco’s De sphaere, one of the most popular works on astronomy for about four hundred years. Note Aristotle’s elementary spheres, above which the unchanging stars reside.
Fig. 14: Pieter Breughel, detail of his print “Temperance,” 1560, depicting temperance in foreground (with clock on head; in the background, scholars measure the size of the Earth and the heavens using similar devices.
Chapter Three
Parallax and the Mathematical Tradition

You who wish to study great and wonderful things, who wonder about the movement of the stars, must read these theorems about triangles. Knowing these ideas will open the door to all of astronomy. From this book (one will learn) to measure the distance of the stars from the earth together with their incredible movements and weights, to understand the extent of their orbits, to know the limits that the atmospheres of these dense bodies dare not exceed. These and a thousand other things the triangles will show most accurately.

Regiomontanus, 1460’s

Everything you measure must be measured by triangles.

Sebastian Munster, 1550

For the sake of this discussion, the authors mentioned in the previous chapter are of importance to us in that the contents of their works contain the first two (and the far more accessible) of three traditions that were passed down to the scholars who rediscovered and revivified the classical canon in the twelfth century. For astronomers living in that and following centuries, the De caelo, Meteorologica and the Timaeus came to constitute the most influential part of the classical inheritance of natural philosophy that explained the workings of the heavens. They became part of the bedrock of any university education and after Thomas Aquinas, among the defining documents of Christian cosmology.

The third of the three classical inheritances, standing apart from these descriptive and primarily causally based theories and statements that medieval and Renaissance scholars confronted, was the mathematical tradition upon which predictive astronomy in the West was grounded. This body of work was contained in the literary corpus almost solely represented in the Middle Ages by Claudius Ptolemy in his *Mathematica syntactica*, better known as “The Almagest,” and, equally importantly for us here, in its sister text, the *Geographia*. Ptolemy, the second-century C.E. heir to the researches of generations of Hellenistic scholars, sought to understand the universe not by describing how it came to be, as had Aristotle or Plato, or explaining its structure and appearance (he did that in another work, the *Planetary Hypothesis*), but by using mathematics to describe what we would call its physical mechanics; how its constituent parts lying beyond the moon moved. In the *Almagest* he explained the logic of his tools (physical and intellectual), and used complex geometrical methods for predicting the future positions of the celestial objects he called stars and planets (in this he included the sun and the moon, as did all natural philosophers before the seventeenth century).

In the first chapter of what may be considered a companion volume to the *Almagest*, the *Geographia*, Ptolemy employed the same conceptual ideas found in the *Mathematica syntactica* to describe several means by which cartographers could find the correct terrestrial locations of cities and place them in correct relationship to each other and any other convenient geographical location. Though he described both terrestrial and celestial methods by which locations could be discerned, he insisted that determining their positions by relating them to stellar coordinates was by far the most accurate,
ultimately basing his judgment in this issue upon the then ages-old perception of their never changing natures.⁶⁸

In that the great astronomer was also a geographer (and astrologer), and in that his primary intellectual tool for understanding both realms was mathematical analysis, Ptolemy can be understood to have accepted the idea that the kosmos could be in some ways studied and described as a whole, not necessarily as having two distinct regions, as had his contemporaries who understood the purposes of science to be as Aristotle had explained them to be. The unifying force of this perspective was the mathematical discipline of geometry, already a mature field by the publication of Euclid’s still useful text, four centuries earlier. Ptolemy’s methods for describing natural phenomena, in seeming contradistinction to the premises of Aristotelian philosophers, worked equally well on earth as they did in the celestial region for providing what could be considered to be verified—and repeatedly verifiable—knowledge.

He was by no means the first to use mathematics in this way; his books stand out for us, and in all likeliness survived into our age, because he brilliantly compiled, developed, and explained the ideas found in the works of his numerous predecessors as well as his own; apparently so well as to make his forebears’ works outdated.⁶⁹ His subject matter, in the Almagest in particular: the mathematical measurement and prediction of celestial and terrestrial positions, had this more pedestrian use. As in most ages, people, including the well educated and the powerful, held deep interest in astrology. As counterpoint to Ptolemy’s seemingly modern approach to the subject—

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limiting his discussion almost entirely to mathematical demonstration and chart compiling, one must note the fact that he wrote an equally influential work on astrology, the Tetrabiblos. Given the usefulness of the Almagest (for the mathematically adept) in predicting planetary positions, and therefore casting horoscopes, it is not surprising that its almost seven hundred English language pages survived the collapse of classical civilization in the West, found new life in Islam, and went on to become the standard text on the subject until its first serious competition, Copernicus’ De revolutionibus, was published, just decades before the nova of 1572.

Because his concerns did not of necessity require a physical understanding of the nature of the objects he chose to investigate, or of their origin, Ptolemy used up less space in those aspects of what we consider to be within the modern bounds of the science of astronomy in the Almagest. In no way that I can see however, did the Alexandrian astronomer directly contradict Aristotelian or Platonic theory. His was a universe made up of spheres as was Aristotle’s, their contents just as unchangeable and eternal, pointedly divine.\footnote{Ibid., 600, 601.} Essential to the Ptolemaic understanding of predictive astronomy was the premise that the stars had never changed and would never move away from their assigned locations on the celestial sphere.\footnote{Ibid., 321.}

Ptolemy assured his readers of the value of his epistemological approach to the study of nature, which he described in the first pages of The Almagest. Philosophy, he said, consisted of the disciplines of theology, physics and mathematics. According to the astronomer, the first two of these were better thought of as guesswork rather than sound means of learning about nature. Mathematics on the other hand, was the only tool of
providing pure and unshakeable knowledge. “Hence we are drawn to the investigation (of Mathematics), but especially to the theory concerning divine and heavenly things...for that alone is devoted to the investigation of the eternally unchanging... which is neither unclear nor disorderly.”

To study mathematics was to study divine perfection, which by definition, was immutable. To master that discipline was to be able to study the “heavenly,” the stars above, in the way God meant them to be studied. Mathematics, further, was useful in the study of “physics” since motion, described numerically, could delineate the corruptible from the (ethereally) incorruptible. In describing the nature of all philosophy, Ptolemy seemed to say that the heaven’s unchanging perfection made knowledge possible. Without this distinctly Platonic sense of perfection, nothing (including theology) could be said to be truly “known.”

Given the profound influence his work had on later generations and ages, the insistence that mathematics went hand in hand with divine perfection, with physical incorruptibility, and with the discovery of truth could only add to the authority of the traditional set of documents handed down from scholar to student throughout the ages. Modern readers seem to take it for granted that Ptolemaic mathematical astronomy was a discipline fundamentally distinct in nature from the logical rigors of his age’s concept of natural philosophy. As these passages above illustrate, they are intertwined in that they each claim to be able to provide essential explanations of the same visible phenomena.

72. Ibid., p.36.
73. It is important to remember that, in Hellenistic theory, “physics” is the decidedly non-mathematical study of nature.
their various practitioners observe in nature: one based its utility on its ability to
discover the “causes” of a phenomena and the other was restricted in its intent to
predicting the motions of celestial objects. It is no great stretch of intellect for later
natural philosophers to conclude that the two approaches might be made to complement
each other almost seamlessly.

Medieval scholars had better reason to connect the two celestial models. Ptolemy’s Geographica was mostly unknown in Europe until the early 1400’s. Students of the two authors living before that time can be forgiven if they had thought Ptolemy to have concerned himself only with the nature of the heavens, and that he had considered that region the only one truly worth the serious analysis that mathematics offered. Later readers would have seen that Ptolemy had closely tied the study of the entire universe, celestial and terrestrial, to the concepts and logic of Euclidean geometry.

An example of the medieval respect for the power of mathematics as applied to the understanding of nature, and one that came to bear heavily upon the conclusions of nova observers, can be seen in Ptolemy’s use of parallax. As with other aspects of his work, he was not the first to develop this method of determining celestial distances. Rather, Ptolemy once again acted in part the recorder of previous researchers’ efforts and constructs. Simply, parallax is a geometrical method for determining the relative places of things in the heavens. It relies on the idea that, during the normal course of the day, an observer will see the stars differently from hour to hour. This is because the celestial spheres, rotating around the earth, present different geometrical aspects to that (motionless) observer. The universe is three dimensional, and the moon, for instance, will

74. Lisa Chaia Taub, Ptolemy’s Universe: the Natural, Philosophical and Ethical Foundations of Ptolemy’s Astronomy (Chicago: Open Court Press, 1993).
have different stars behind it depending on what angle one sees it at. Two observers, at opposite ends of the Earth will see different stars positioned at the Moon’s edges, even if they look at the Moon at the same time.

Given that some methods of parallax measurement can produce numerical results (measured in an arc of an angle) they can in theory be applied to measure the absolute distances between celestial objects. I will explain this in more detail later, but for now it is important to note that, for close by neighbors like the Moon, parallax is easy to measure, being at times up to three minutes of arc (within two minutes things begin to get difficult to separate visually). To the naked eye observers of the pre-telescopic age, the stars in the heavens were thought to be immensely more distant than the Moon as no stellar parallax however small had ever been observed. This was a point that Ptolemy made abundantly clear.\(^\text{76}\) Since there was no recorded instance of relative stellar motion beyond the eternal, deified spherical realm of the planets, he wasted no time discussing even how one might otherwise use his tools to determine their distance. Lunar parallax was discoverable (he claimed to have made very accurate measurements himself) and so the Alexandrian described his method for finding that body’s variation, and his instrument for doing so in rather great detail.

Note: parallax works just as well on an Earth that is standing still at the center of the universe, as with an Earth that is orbiting the Sun. Copernicus, and the nova observer Thomas Digges, both understood that the consequences of this parallactic theory as applied to his heliocentric model implied that the universe was far bigger than previously thought; an orbiting earth had a far larger “base” upon which to make measurements.\(^\text{77}\)

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76. Ptolemy, 322.
The absence of a parallax error in a heliocentric universe could only mean that the stars were much farther away than the geocentric Ptolemaic tradition suggested. That later astronomers, such as literally, every recorded observer of the nova of 1572, accepted the mathematical concepts at the heart of the theory of parallax is indicative of the West’s longtime faith in the idea that mathematics was a useful tool in the study of nature. There is much more to say on this topic: parallax was on the minds of just about every natural philosopher who observed the heavens in the sixteenth century.

It is ironic that the work of one Alexandrian, superseded by and therefore discarded because of the usefulness of Ptolemy’s *Almagest*, might have extended our current knowledge of the understanding of novas in the ancient world, had it survived. Hipparchus, from whose observations and methods Ptolemy draws extensively, was recorded by Pliny as claiming to have seen a new star around the year 160 B.C.E. No more detail is known about this star through other authors, except that the sighting was noted by the Roman encyclopedist, 250 years after the fact, and that, according to Pliny, so inspired by this nova, Hipparchus went on to create a catalog of all the stars, including in that list a system of positioning them which was copied and expanded upon throughout the following millennia.\(^7\) This list is though to be the one found in Ptolemy’s compendium, and as such, through one translation after another, became the “official” list of stars and their locations until the end of the sixteenth century.

Hipparchus is thus well known among modern students of classical mathematics and astronomy if only by the reflected light his work cast. Few of his own writings

\(^7\) Pliny, *Natural History*, vol. II: 161.
survive, but much of Ptolemy’s use of observations dating back as far as the 8th century B.C.E. are thought to be derived from his work. Hipparchus therefore is of even greater interest for this study because of where he was at the time he recorded that data. Working in Alexandria as he did, when he did, he would almost certainly have had an excellent chance to examine records of Babylonian astronomical observations that by then seemed to have found their way to the cities and scholars of the Mediterranean basin. Ptolemy, living more than 300 years later in the same city made use of them. It can only be speculation that Hipparchus, perhaps not so enamored of Aristotelian ideas of perfection, and having evidence of the existence of alternate models from far more ancient and detailed sources of information, would have had no trouble seeing the novas that others were convinced couldn’t occur. No other reference to a new star exists in the classical tradition before its recovery in the eleventh and twelfth centuries.

The *Almagest* vanished from West Europe for some six hundred years, to be brought back into the collective consciousness of medieval intellectual life at the beginning of the twelfth century. By happenstance, the *Geography* reentered the canon considerably later, at the beginning of the fifteenth century. In that period of transmission, the astronomical work’s original Greek was converted to Arabic, and from Arabic to a less than classical Latin. In this form it by and large remained until the fifteenth century. While many Latin scholars struggled to make sense of its mathematical subtleties, most looked to the simplified, descriptive texts like Sacrobosco’s early thirteenth century *De sphaera*, or a beginner’s math guide like any one of several books

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79. Ironically, Hipparchus’ only surviving work is a commentary on Aratus’ *Phaenomena*. He is credited with writing a treatise on parallax however, which makes him the oldest known author on the subject.  
80. Lester: 143.
given the title *Theoricae planetarum*. Each based upon a conflation and reduction of the *Almagest* and *De caelo*, these all served their thirteenth- and fourteenth-century readers who had varying levels of geometrical knowledge and skill. In the 1280’s the *Almagest* served as a guide to Spanish astronomers who had been ordered to create an ephemeris which came to be known as the Alphonsine tables: essentially a set of lists of predicted planetary positions. These tables in turn served ubiquitously in the West as the standard celestial tables until the sixteenth century.\(^{81}\) While medieval scholars pulled no punches when it came to criticizing many of Aristotle’s ideas and theories, there was deafening silence when it came to the questioning analysis of the Alexandrian astronomer’s mathematical study of the heavens.

By the 1470’s however, the humanists’ decades-long efforts at restoring the corrupted body of classical literary and astronomical knowledge that was described in the previous chapter also began to bear fruit on the tree of natural philosophy: the most important result of these efforts came in the form of George Peurbach’s rewriting of the medieval classic *Theoricae planetarum*: his *Theoricae novae planetarum*, completed and published a decade after the author’s death by his student Johannes Regiomontanus, in 1474. The work became an instant success and an academic standard—apparently far more studied that the *Almagest* itself—one of the first astronomical books printed, and among the most published astronomical texts of the age.\(^{82}\) Like its medieval predecessors, the *Theoricae novae planetarum* relied extensively on a confection of Aristotelian theory and Ptolemy’s *Almagest* as its reference point. In order to make the Alexandrian’s work more accessible, Peurbach removed the long and abstruse mathematical reasoning which

\(^{81}\) Lindberg, *The Beginnings of Western Science*: 258.

\(^{82}\) This is not hard to understand; the *Theoricae* is about one sixth the length of the *Almagest*. 89
he had used to prove his theories, and left a numerical and geometric description of the movements of the Sun, Moon, the planets and stars. In comparison to the twenty-four odd pages of descriptive writing that made up the *De Sphaera* of Johannes Sacrobosco, Peurbach’s one hundred twenty three pages include a far greater collection of detailed and complex ideas about the motions of the celestial realm. As important as it was for providing access for less mathematically adept readers, it broke no new ground in the geometry and physics of astronomy. For the brightest minds of that age, classical tradition still held out the greatest possibility of true understanding. According to Peurbach and his famous colleague and student, the heavens were as Aristotle had said they were, made of crystalline spheres, and by implication, and a pronounced silence on the matter, changeless and immutable.

Had these been the final contributions of writers to the art and science of astronomy before the arrival of the nova, perhaps we would have less curiosity about the response it received. Much happened, however, between the late fifteenth century and the year 1572 that indicate a sea change was occurring in peoples’ understanding of the universe. As has been noted earlier, these one hundred years were the heyday of the science of cosmography. Inspired by the ongoing discoveries of the western continent, natural philosophers responded to the rapidly expanding realm of human knowledge presented them. They also quickly deduced that a considerable part of the ancient

83. George Peurbach, “*Theoricae Novae Planetarum*, a Translation with Commentary,” *Osiris* (1987). The entire volume is given over to this text.
tradition of natural philosophy did little to explain the nature of the new world, the extent of which seemed to be constantly growing.  

The silence one finds concerning the nature of stars—a central theme I have tried to drive home here—should therefore seem even more mysterious to modern readers familiar with the age’s discoveries. To add to this apparent contradiction, one may point to contemporary astronomical literature, not solely because of its contents alone, but also for the sheer volume of that literature; the breadth of which one would imagine must contain some evidence of curiosity concerning stellar history. The sixteenth century after all saw an explosion of interest in all matters cosmographic: astronomical, geographical and cartographic, those subjects then intimately connected by authors who almost always intertwined the three, working to find new ways of thinking about the world around them.

It is a good indication of the age’s active and growing interest in celestial and terrestrial matters that so much material on the subject was marketed. It has been estimated that, up until it was first put into print, the Geography existed in the form of about seventy five manuscripts across Europe. Between its first printing, in 1476, and the end of that century, the number of copies grew to over one thousand. Far from being seen as obsolete, Sacrobosco’s short treatise grew in size, as I have mentioned, to Clavius’ six hundred pages by the end of the century. He was not alone in his loquaciousness: Erasmus Schreckenfrucks’ commentary went to over seven hundred. These particular versions would have been for the scholar and the professional

astronomer, of course. Most of the century’s two hundred odd other editions of De sphaera (considered a conservative estimate) would have carried commentary on many other levels. During the course of the 1520s while he was head of the Casa de Contratacion, for instance, Columbus’s son Hernando chose De sphaera as the primary text for teaching his student pilots about celestial navigation. Clearly Sacrobosco’s description of the universe was congenial to the intellectual perspective of the age.

De sphaera was not left to stand by itself. Gregor Reich’s Margarita philosophia, a popular standard discussion of philosophy containing a detailed explanation of our now familiar cosmological mechanisms, was reprinted eight times between 1503 and 1535. Jean Fernel’s Cosmotheoria (1528) carried calculations of the size of the Earth and Sun. The works of other serious and talented intellectuals like Peter Apian, whose life paralleled that of Copernicus, remind us that every age has its enthusiastic popularizers. Apian, court scholar to Hapsburg Emperor Charles V, published two influential works on astronomy: the first, in 1524, titled Cosmographia liber,\textsuperscript{88} the second, the widely read Astronomicum caesareum in 1540. They were both were immediately understood to be among the most useful astronomical texts of the age. Both were therefore widely copied, plagiarized and pirated. Apian used a number of innovative tools to explain the movements of the heavens; he created and printed in his first book paper circles superimposed upon one another, each inscribed with planetary positional data. These volevells could be rotated to imitate the positions of the stars and planets, and as such they constituted simple astronomical calculators. The central aim of Apian’s efforts was


to teach the basic ideas of cosmography by giving the reader a tool to calculate the positions of celestial objects, and therefore come to understand the motions of the heavens themselves. At the outset, Apian showed his reverence for classical tradition, describing the entire cosmos as did Aristotle and Ptolemy: a spherical earth divided into zones; the heavens divided into the ten circles detailed in De sphaera; the celestial regions made up of incorruptible and unchanging quintessence. Throughout the entire body of the work, the trans-lunar world was portrayed as a somehow powerful and majestic creation of God’s divine intelligence. It was for Apian, like Aristotle’s reasoning and God’s wisdom, absolute, unchanging and unchangeable.

Peter Apian’s works were “revised” by the cartographer Reiner Gemma Frisius and republished. To the many editions of the Cosmographia Frisius saw into print were added a volume that combined the study of astronomy with geography, called Libellus de locorum which explained his techniques for using trigonometric functions to chart the exact locations of town and cities. Both versions, Apian’s alone, and with Frisius’ additions each saw, literally, scores of editions in the sixteenth century; of the combined version at least 60 are known.

Caspar Peucer, the Protestant theologian, Michael Maestlin, tutor of Johannes Kepler (all nova observers: the first two in 1572, Kepler in 1604) and Oronce Fine, French mathematician, all published popular astronomy texts that discussed the subject from various levels of complexity and subtlety. To these one must add the vernacular

91. Gemma used the word “revised,” as little was added except his new star positions, perhaps “plagiarized” might be more accurate.
92. Johnson: 300.
works made to edify the increasingly literate mid-levels of society—Robert Record’s *Castle of Knowledge*, a popular mid-century English text mentioned in the previous chapter, is a good example.

In the decades before the nova, popular and professional interest in astronomy grew rapidly. This growth must be put in context however; interest in virtually every aspect of the study of nature that might be listed under the heading of cosmology grew widely across the continent. The geometric concepts preserved and presented in Euclid’s thirteen volumes were seen as useful to the understanding of, and capable of being applied to, every facet of the “new science.” Authors published important works on mechanics, architecture, the uses of perspective, surveying techniques and fortress and artillery design, all heavily reliant on the more commonly understandable mathematics of geometry.  

In order to put these ideas to good use (mechanical practicality being another hallmark of the intellectual age) a new profession was brought to life: that of the mathematical practitioner. As well as working to fulfill his employer’s engineering and architectural needs, the mathematical practitioner worked to understand the uses and limitations of contemporary navigational and surveying equipment. The sixteenth century saw a concomitant growth in instrument development and manufacture. Virtually every astronomical text published in the sixteenth century contained chapters on the construction and use of measuring instruments. Copernicus’ *De revolutionibus* did, though the author limited his device’s use to the predictions of stellar positions. By way of contrast Gemma Frisius’ “*Astronomici radii,*” to which he devoted scores of pages in

his *Libellus de locorum*, was markedly useful on land, sea and for stellar observation. The English mathematicians John Dee, Leonard Digges, and his son Thomas—an important observer of the nova—wrote extensively on and designed numerous mathematical surveying instruments.\(^95\)

Few who wrote on any generally mathematically oriented subject failed to add their own ideas. Witness Ignatius Danti, Dominican friar, Medicean mathematician and cartographer’s study of the astrolabe: “*Trattato dell uso et della fabrica dell astrolabo,*” published just four years before the nova’s arrival, or Peter Apian’s *Instrument Buch* of 1533. The final word on instrument making in the sixteenth century was the product of a lifetime in the business, Tycho Brahe’s collection of designs “*Instauratio mechanica*” included the instructions for construction and operation of no less than twenty-six devices, some to be built on a grand scale. Tycho, ever concerned with the work of others in his field, once sent an assistant to Frömbork, at the eastern end of the Baltic, to acquire the astronomical devices that had been built by Copernicus.

Lest I have failed to make my point, and readers still imagine that the design and manufacture of devices for measuring geographical terrain, the bounds of the ocean, and the heavens, was some small side interest of an obscure substratum of philosophical enquiry, I direct them to the Oxford Museum of Science whose website, along with the collections of other European museums, is a treasure house of evidence to prove otherwise.\(^96\) The site contains no less than 530 such instruments, manufactured by 132 different craftsmen, from the middle of the fifteenth century up until the end of the

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96. [WWW.OX.CA.UK/epact](http://WWW.OX.CA.UK/epact), last visited April 14, 2012.
sixteenth. The size and diversity represented in this collection is impressive, an indication of the measure of interest and creativity the age held for innovation in mensuration. These instruments: quadrants, astrolabes, sundials, surveying instruments, among the many species, are examples of accuracy and refined artistry. As virtually all in this collection are made of expensive materials such as brass or ivory, and exhibit sometimes brilliant craftsmanship, one may well imagine that they are the “high end” products of the industry and extrapolate from this the much higher percentage of similar equipment that was made for the work-a-day uses of ship board navigation, or astrologer’s nocturnal vigils. Among those displayed are two “mathematical triangles” made by Ignatio Danti, clocks made by Wilhelm IV’s mechanic Joost Burgi, and quadrants by Thomas Geminii, all of whom will step on to the stage illuminated by the nova’s light at one point or another in this study.

That these instruments were, at some level, familiar to the non-technically inclined is made evident in the paintings of Hans Holbein, who worked in (the then technical backwater of) the court of Henry VIII, in the 1530’s. His work, “The Ambassadors,” portrays a wide array of exotic astronomical instruments (see illustration on page 230). Whatever his purposes were for including them in that painting, their addition must imply that the casual, courtly viewer would have had some understanding, and appreciation of their uses.97

Another useful tool that came to maturity in the decades before the nova was the globe. While the idea of projecting the surface of the Earth on to a sphere was certainly not new in the late fifteenth century, the craft and the demand for globes matured as news

97. A detailed description of these instruments, and an interpretation of their symbolic meaning can be found in: John North, The Ambassador’s Secret, Holbein and the World of the Renaissance (London: Orion Books, 2003), especially Ch. 6.
of discoveries in the ocean seas excited interest among literate Europeans. One current study lists over 150 editions of globes that were manufactured in the sixteenth century. Subject matter was not limited to the Earth’s surface features by any means. Manufacturers often produced pairs of globes; one being terrestrial, the other celestial. On occasion, designers put geographical features, terrestrial coordinates and stellar positions all on one sphere, indicating the unity of the universe portrayed in their works.98

Perhaps more importantly than new discoveries, new tools and vastly increased reading public, in the waning years of the fifteenth century, the matured and increasingly effective mathematical discipline of trigonometry was brought into the broader world from the pages of ancient texts. It proved to be the perfect means for solving earthly as well as celestial mysteries. Cosmography with this new underlying mathematical doctrine that seemed to offer such great potential, quickly came to assume the position of an all-encompassing discipline; an interconnecting web of ideas based upon the assumption that the whole universe must have a common central premise by which its meaning could be made clear. That central premise: that applied mathematics and observation, rather than logical deduction and authority, were the most powerful tools man had his disposal, was beginning to be made publicly in the literature of the age. The basis of that claim, in large part, was the ongoing success of trigonometric analysis in solving geographic and navigational problems.

As with many innovations of the age, this new science was not produced sui generis out of the minds of Renaissance thinkers. Medieval astronomers knew that the Almagest’s first books contained the theoretical basis of the “chord,” what is commonly

called the sine function in modern trigonometry. This is however, as far as ancient mathematical thought went on the subject.\(^9^9\) As a reference, Ptolemy’s chord tables, worked out in Book One in great detail, nevertheless were of limited value, both conceptually as well as practically.

In the centuries after the collapse of the western empire, the basic functions found in Ptolemy’s works were elaborated upon and expanded by Muslim mathematicians. By the beginning of the fifteenth century, a complete set of trigonometric functions could be discerned and ingested from Latin translations of their texts. Those working to understand their import, most importantly for our discussion George Peurbach and Johannes Regiomontanus published these innovations, and proclaimed their advances to be of the greatest value to the cosmologists of the age.

Unfortunately, their timing was a bit off. As I have previously noted, Puerbach’s great work on the subject, *De triangulis omnimodis*, was not put into print until 1533, long after his death. Not that scholars in the decades between his death and his book’s publication were unaware of the work; the existence of manuscripts was common knowledge. The printing of this text caused somewhat of an explosion of interest in the subject, as well as the creation of a public dialog on the uses of trigonometry in the measurement of the physical world, a prime concern of cosmologists.\(^1^0^0\)

Almost to a man, the observers of the new star, who had wondered over the new instruments, globes and publications, were also taken by the new science. To have read and digested Ptolemy’s and Euclid’s works was to have acquired a large and detailed body of ideas and tools with which to mathematically analyze nature. But these were now

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\(^1^0^0\) Ibid, “The West to 1550.”
two thousand years old, and they had their limitations. For the purposes of what they imagined they needed to understand and know—to map and measure the entire cosmos—fifteenth and sixteenth century natural philosophers found new devices to overcome the deficiencies of the classical inheritance. The most powerful of these was the new mathematics of triangles.

Few interested in the age’s innovations were immune to the possibilities. Johann Rheticus, famous for his efforts to coax a reticent Copernicus to publish his ideas about heliocentrism, had no apparent trouble convincing the Polish mathematician to publish the chapters of his De revolutionibus that dealt with the new trigonometric methods of the age.101 Gemma Frisius quickly used Peurbach’s ideas to invent the modern discipline of surveying. In 1573, as he watched the nova from night to night and measured its position among the stars, Tycho Brahe used Peurbach’s system of triangulation, praising it as a great advance over the methods of the ancients.102

Not only had the new age begun to produced better, more accurate measuring devices, it had, in the new math, produced a small but important revolution in the way that observers conceptualized the universe. To examine our collections of the rediscovered works of the ancients is to observe an image of the universe that is essentially—it bears repeating—stable, immutable and unchanging. It also comes across in the medieval texts’ illustrations as conceptually two-dimensional In the centuries before the publication of Regiomontanus’ book, authors created images of the mundus that lay flat on the sheets of vellum they were drawn on. In order to make any sense out of them the reader had to be told that the diagrams he or she were examining were in fact

101. See Copernicus, De Lateribus et trianguliis (Vittemberg, 1542).
102. Tycho Brahe, Stella nova, folios B and B2, ff. Tycho describes Regiomontanus’ method, mentioning him by name five times in just a few pages.
depictions of a three-dimensional universe. Nothing is intuitive about the collections of medieval drawing that explained the methods used by Ptolemy. To be sure, medieval and Renaissance natural philosophers had a perfectly good idea as to the spherical nature of the universe: woodblock prints of the spheres described by Sacrobosco are reasonably adequate to project the sense of sphericity that the written texts describe (see illustration on page XX). Mathematically, however, received tradition had failed in this matter. The tools of measurement and understanding given to the age of the nova by Ptolemy and Euclid, for all their usefulness, left much to be desired when it came to grasping the means of understanding how to do the work that cosmologists knew needed to be done: that of measuring the entire cosmos they observed around them in a precise and meaningful fashion.

At the beginning of the sixteenth century, starting, I suggest, with the manuscript and later, published works of Georges Peurbach, a different set of illustrative rules began to appear on the pages of the scientific texts then just becoming so popular. By the middle of the century, imitating the fourth book of Regiomontanus’ study, the mathematical principles of the new science began to be explained in three-dimensional representations that portrayed in far more accurate and naturalistic terms the physical nature of the universe. These new images of the heavens and of the earth were indicative of the greater conceptual understanding of the world that the new mathematics had produced.

In looking over the late sixteenth century’s astronomical artifacts one is struck by the vast quantity and diversity of intellectual understanding they represent. The sheer
volume of printed literature hints at the popularity of the subject and the varieties of understanding. Rapidly evolving features on maps and globes—terrestrial and celestial—indicate among many things the level of excitement about the changing nature of cosmological knowledge. New tools for measuring the physical dimensions of the cosmos tell us of their makers’ desire for increased power and efficacy, and the growing ability of contemporary investigators to delve into nature’s secrets.

Still, for all practical purposes, the age uniformly understood the physical nature of the celestial region to be as Aristotle had imagined it to be 2000 years before, his authority in this matter in no way diminished among those who watched the heavens. For all the possibility of change these intellectual forces brought to the received classical tradition, to sixteenth century astronomers and philosophers the heavens remained immutable and unchanging. Beyond the struggle to find the logic of the heaven’s motions there remained a curious, resounding silence about the nature of its contents throughout the entire Western canon of astronomical thought. Tycho Brahe, to whom we shall turn to shortly for most of our reporting about the new star and who, it will be shown, had mastered the most advanced mathematics of the age, invoked the name of Aristotle (as well as Hipparchus, and Copernicus) when he needed philosophical backing for his mathematically based theories and statements.

Change was waiting in the wings. By the middle of the century in which the nova appeared, the body of theory and knowledge that the Western world took to explain its presence had undergone a two millennia-long evolution. It was not the system of natural philosophy that Aristotle had found, criticized and molded to his own sensibilities. If his celestial physics had faced little challenge, his grander model of the physical world had
been repeatedly challenged and newer, more cogent ideas had sometimes come to the fore. Christianity had brought powerful intellectual and emotional forces to bear upon these ideas and theories. Further, the science of astrology had given different meanings to the heaven’s order. The new discoveries of the age and the development of the science of cosmography in all its manifestations produced an entirely new perspective on the understanding of nature.

Like everyone else, Europeans: whether university educated doctors or peasant farmers, merchants or craftsmen of the town, soldiers or navigators, were ardent observers of the celestial world and the goings on in the skies above. It therefore may be difficult for the modern reader to imagine that seemingly everyone who had the means to record them, had, in the past 2000 years missed the bright new lights that from time to time would grace the night sky. For whatever else it can tell us about those people, one might find that this centuries long silence is a good gauge of the ability of theory to color one’s experience of the world. More importantly for this study, it is a valuable backdrop to the clamor raised when that silence was broken in 1572.
Chapter Four
Who Saw the New Star?
The Astronomical Community in 1572

First he assigns a place in the expanse of heaven to the planets and stars; but astronomers make a distinction of spheres, and, at the same time teach that the fixed stars have the highest place of the firmament...The stars when they run their course, at once adorn the heavens and give light to the earth...Eclipses, and other things which we observe plainly show both that the fixed stars are above the planets, and that the planets themselves are in different orbits...the work of the second day is to provide an empty space around the circumference of the earth, that the heaven and the earth not be mixed together since the proverb “to mingle heaven and earth” denotes extreme disorder. This study is not to be reprobated, nor the science be condemned...for astronomy is not only pleasant, but very useful to be known: it cannot be denied that this art unfolds the wisdom of God...how great would be our ingratitude were we to close our eyes to our own experience?

John Calvin, 1540’s

In order to trace an orderly path extending from the traditional, received cosmology of classical and medieval civilization to the birth of a modern mathematically premised science, modern authors have sometimes found it necessary to limit the retinue of their subject astronomers. This is neither misleading, nor essentially wrong as a means of describing what had happened to a sub-field of natural philosophy between the year 1543 and the publication of Isaac Newton’s *Principia*, in 1687. After all, if they had set out to describe the ideas and the events that had caused the intellectual transformation of a tiny group of scholars that made up several generations of Europe’s mathematical virtuosos;

those for whom, its own author makes clear, *De revolutionibus* was specifically written, modern writers could do worse than quote the words of those great investigators of nature.\(^{104}\) Copernicus’ and Newton’s two works are, so to speak, the bookends that hold between them the canon of the revolution that numerous authors have tried to describe and explain.

In this reading of the intellectual events surrounding the publication of *De revolutionibus* the cosmos was ultimately measured, and understood, by the mathematical demonstration of perfection. Accordingly, Copernicus knew he was right; not so much because he had *observed* that the earth moved around the sun, nor that his model had proven to be so much more accurate, but that to remove Ptolemy’s equant and preserve the sanctity of the sphere was somehow more satisfying intellectually. Heliocentricity certainly accorded well with his belief in platonic perfection; and it served his purposes even more so, in that yet other ancient theorists, whose work had just as much been hallowed by time as had Aristotle’s, had suggested just such a world order.\(^{105}\)

Carrying on the literary and philosophical tradition of his immediate intellectual forefathers, Nicholas Copernicus sought nothing less than the restoration of astronomy to what his contemporaries assumed was its ancient soundness. He, unlike most of the age’s astronomers, could do so by taking on Claudius Ptolemy on his own mathematical turf. For the rest of the scientific world, the beginnings of any suggestion of the *physical* accuracy of his theoretical ideas could only come into existence after the publication of the Prutenic Tables in 1551, years after his death. Until that moment, natural philosophy

\(^{104}\) Copernicus, *De Revolutionibus*: 7.

had no workable, practical alternative to the tried and tested Ptolemaic-Aristotelian world order. Not that Erasmus Reinhold’s translation of Copernicus’ techniques into a usable reference caused many to accept the heliocentric theory; despite the improvements in predictive accuracy that the tables offered, they produced results that were by no means entirely accurate. Prutenic predictions brought lunar eclipses within a few days of their actual occurrences, rather than King Alphonso the Wise’s weeks. Most, it seems, who used the tables in the last decades of the sixteenth century preferred to profit from their increased accuracy and not think about their progenitor’s theories. 106

One way of making my case, that the revolutions of astronomical and physical sciences that took place at that time also had other, broader causes than those highlighted in works that follow this narrow logical path, is to describe the community of natural philosophers that took notice of the new star. Naming the names and describing the lives of those present and actively observing at the time serves my purpose well; I may then ask: how many of these appear in modern historical accounts? Were they not practitioners in the exact same way as was Copernicus? The nova’s observers—and there were many—were very much inclined to use the several logical, mathematical and instrumental means at hand that I have described in their analysis of the strange new object above them. They were the direct intellectual heirs of Aristotle, Plato, Ptolemy and Copernicus after all; none I will introduce here in this chapter did not immediately grasp the ideas at least, of the tools that the canon of Frömbork would have recognized and

used himself, had he been alive in 1572. Whether they agreed with his thesis or not, many, if not all, were familiar with his work and ideas.

As it turns out, far more people had active interests in the goings on in the super-lunar sphere than one might be led to believe by authors who have concentrated on the Copernican-Newtonian narrative, and for more varying reasons. As I have described above, in the decades before 1572, a sea change in how people saw all aspects of the world was well underway. The nova focused the attention of many disparate groups of interested parties on the heavens, making the celestial realm momentarily the latest “hot spot” of Europe’s intellectual industry and its growing technological support structure. In the decades before the nova, no less than an emperor, his physician, a king, a duke, his cosmologist, three German princes and two high ranking (and therefore rich) members of the nobility, a succession of Popes, the Society of Jesus, Dutch map and globe makers like the ones who made the devices I described in the last chapter, British mathematicians and instrument makers, publishers and popular writers across Europe, and a score of well known academics, public officials and well read merchants scattered around the town and universities of Europe—not to mention an army of astrologers of various social and intellectual persuasions—all passed letters, traveled great distances to meet each other, studied Ptolemy’s writings and *De caelo*, Sacrobosco’s *De sphaera* and Apian’s *Cosmographia*, struggled with *De trianguliis*, and shared ideas and astronomical projects. Each one of the generation of natural philosophers who saw the star could have not failed to come to their own conclusions about the bright visitor above them. They were all, to varying degrees, the inheritors of an ancient, multifaceted intellectual tradition, and as

107. Almost unnoticed in the bibliography of Copernicus’ writings for instance, is his book about the new trigonometry, called *De Lateribus et angulis triangulorum*, published is 1542.
well, a century of technological and mathematical development that augmented and challenged a mature system of logical argumentation to come to conclusions and find answers to their questions about natural phenomena.

The individual who came to be our greatest transmitter of nova research, Tycho Brahe, knew many of the cast members and crew, so to speak, and was actively and firmly connected to the web of communication they spread across Europe. From our perspective, he seems to have been at its center; his compilation of nova reports has become our primary source of knowledge about it. This is chiefly because of the work of J.L.E. Dreyer, who spent the last decades of the nineteenth century editing and publishing Brahe’s collected papers. To him we owe no less than 310 pages of commentary and mathematical examination of the nova, if one includes Tycho’s 1573 *Nova stella*, his rapidly sketched first account. The *Astronomiae instauratae progymnasmata*, which makes up the bulk of those pages, was published posthumously, in 1602. It provides a record of the writings and opinions and researches of dozens of Tycho’s colleagues. I am sure that without Tycho’s (and Dreyer’s) dedication to the subject, we would be largely in the dark about the events of 1572 that I shall describe later in this study.

Readers examining his accounts must remember that Tycho was in some ways like his contemporaries, and in other, very important ways, not. Like other young Europeans of the day, the Danish nobleman spent years of his early life drifting between one German university center and another, studying law in his parent’s anticipation of his being given a post in the court of the Danish king Fredrick II. In those years, he thoroughly examined and came to understand the body of Western natural philosophy, both ancient and new, that pertained to the study of the heavens. In this he was like many
other young university students of any age: he accepted the fundamental tenets of his
times; for him this meant faith in the efficacy of astrology, the surety of the ancient’s
celestial models. Despite the radical challenges that the next several decades would pose
to the subjects of astronomy and physics, he never gave up on one of their central tenets:
the idea that the earth stood still. Brahe, as did every living soul in the Europe of his time,
fervently ascribed to one or another of the then multiplying sects of the Judeo-Christian
religious tradition. He could never doubt that the heavens were made by God, for some
purpose, which man could and must come to understand.

He was however, even as he was working his way through his law books at
Leipzig, becoming far and away one of the finest observational astronomers of the age.
Years before the nova changed his life, as a young man in the 1560’s, he became a
talented mechanical instrumentalist; he was, unlike many of his rank, quite willing to
work with the craftsmen he came across in designing and making experimental
observational equipment. Tycho had the luxury of knowing that he was soon to be one of
the wealthiest and most politically connected men of his times. In short, Tycho Brahe was
unique in his astronomical and technical leanings, and he had the cash to make his ideas
come to fruition.

When we read his later comments about the new star, remembering that they were
put into print after his death, we must remind ourselves that these had been developed,
mused over, and argued by one of the finest astronomers of the late sixteenth century.
They had been incubated in the heat and light of the by then decades of observational
progress that he himself was responsible for. By the 1590’s, Tycho had had the
opportunity presented by years of practical experience and debate among peers to pick
and form his arguments, choose with whom he would agree and disagree and therefore, to some extent, whom we would know about. Ultimately, this gave him control of the logic, the facts, observations and the ideas with which he would make the most cogent and important points of what has become our most important collection of documents. Repeatedly throughout the text he made reference in his arguments about the nova to events that had happened long after the nova itself had faded from view. These included the comet of 1577 and letters from his colleagues sent in 1585. He seems to have recorded happenings that fit in well with his (or not well with his opponent’s) astrological prognostications, one suspects, to score points against people in all likeliness, long dead. 108

The far shorter *Nova stella*, written while the star still shone (28 years before the *Progymnasmata*), is, like Tycho, both unique and very similar to its sister publications. Its tenor is hasty and exited, and it reads like a news report rather than a natural philosophical treatise. It states Tycho’s observations: the star’s position measured against its stellar background, its changing colors, with an urgency that reflects the awe and excitement of the moment. Its author is concerned to communicate his conclusions to his immediate contemporaries: the meaning (s) of the star in light of the age’s obsession with astrology, its devotion to its particular religious causes, and the doubts it casts upon existing cosmological theories.

Both types of documents are of necessity important to us, and they are as different in their purposes as were the intellectual experiences of the man writing them. For these reasons, we must make a strong effort see his work with a critical eye, and

108. Nova observers Ioaness Praetensis (1576), Wilhelm IV (1592), Fra Maurolico (1575), Paul Hainzel (1581), whose work Tycho published and commented upon at length were all dead in by the early 1590s.
equally so, to understand why historians have been so willing to give him such a high standing among the astronomers of the age. In reality the cosmological republic of letters he sometimes appears to have governed had no one capital; its citizens were scattered across confessional divides, national borders and political and economic classes. To date, I have recorded the names of some forty-five professional scholars and observers who recorded their thoughts on the nova. Others have claimed to have noted as many as fifty.  

Many of these wrote entire books on the nova, some more than one. It is quite clear from the comments made in these books that still more were profoundly interested. That this is the case was clearly made by Tycho himself, when he included the comments of so many authors in his later work, and also by the fact that we possess the complete works of others who wrote in depth about the nova, much in the same way as did Tycho, and that much of their writing does not appear in Brahe’s compilation. Who might some of these observers be? How can we find out about them without the aid of Helmann and Dreyer? What motivated their interests? These are concerns I will discuss below.

So, to repeat one question, the answer to which may seem obvious: why would so many find the heavens so captivating, and so important? The first of many responses to this inquiry has been approached already: by the end of the Middle Ages, a Christianized Hellenic philosophy had come to crown knowledge of the Creator’s wisdom before mankind for all to see, in the sky above. This lovely philosophical trope had the effect of

110. See my Appendix B for observers, titles, and references.
placing a very tangible burden upon those who had invested in the particular doctrines and ideas they derived from the stars: the onus of publicly defending their own interpretations of God’s stellar message; the one they themselves took from the celestial firmament.

Until the middle of the sixteenth century, little serious concern was placed upon the clarification and formalization of varying meanings of celestial phenomena beyond the intramural disagreements of academics. With the rising tensions generated by the Reformation this changed. More than had ever happened before, disputing theological camps throughout the age of the nova worked to define and codify all aspects of their beliefs. Not only did Catholic and Protestant teachers organize educational curricula that conformed to their broader intellectual sympathies, they built pedagogical programs to disseminate and promote them, and to actively defend them, and discipline those who disagreed. An ideological element so basic as one that described the nature of the universe could not be left out of the process. ¹¹¹

By the year of the nova, for instance, the newest of the Catholic orders, the Society of Jesus, had constructed its own network of colleges and had developed subtle and rigorous defenses of the Thomist philosophy. At its heart stood Aristotelian physical understanding of the cosmos. Jesuit teachers and scholars were themselves increasingly trained in mathematics and concurrently, astronomy; this being for all practical purposes Ptolemaic in form. To be educated by the Jesuits was in turn to be immersed in, among many subjects, theology, mathematics and astronomy. All three were solidly interconnected, and part of the Church’s fundamental belief system. A well organized

bureaucracy, its presence in the courts of Catholic Europe and its interconnected web of literate professional scholars and teachers that made up the faculty of some five hundred colleges and schools ensured that the order’s many students (of any given social class) were well aware of the works and ideas of astronomers anywhere in the Catholic world.\(^{112}\)

The Protestant North had inherited, ingested and invested itself in the same classical traditions, and came to have just as much to defend in them.\(^{113}\) For whatever the emotional force of theological issues that inspired and divided Europe’s intellectuals in the second half of the sixteenth century however, few had much to disagree about when the discussion turned to the nature of the heavens above. To be an educated Christian was to be educated at some level, in astronomy; to be an educator was often just as well to be a foot soldier, or at least an active civilian participant, in an ideological war.\(^{114}\) Regardless of one’s other religious sentiment however, the heated religious debates of the age ensured that an educated person was someone who was versed in some level of Ptolemaic and Aristotelian theory, and understood that this knowledge was of paramount importance.

The second answer to the question—what did people find that was so useful in a collection of cold, distant and unchanging stars—that comes to mind, and the easiest to elucidate, is that overwhelmingly, Europeans of every faith believed that the heavens in some way guided their fates. Celestial objects, it was clear to all, held some form of sway


\(^{114}\) Max Caspar, Kepler, C. Doris Hellman, trans. (New York: Abellard - Schuman, 1959), notes the mathematician’s exile from Styria because of his religious beliefs.
over the terrestrial world: The Sun heated the world and fed it the forces of life. The Moon moved the ocean and aided the reproduction of animals. Planets seemed to evince more subtle but just as powerful influences upon men’s lives. Few people could ignore these observed realities, even if they did not understand how they worked. Undoubtedly much of the age’s interest in astronomy stemmed from its assumed predictive value: as the means of knowing when planets would be in what constellation, and what phenomena like conjunctions and fiery trigons would occur.

It is fair to say that the trade in ephemerides (books listing positions of planets for the year to come and therefore of great importance to astrologers) made a larger contribution to the coffers of printing houses across Europe than that of the educational texts I have enumerated, and hinted to publishers what the curious reader might want next from his book seller. A still better measure of the power that this idea held over people’s imaginations is apparent in the vast spectrum of matter written on the subject, from common prognostications to the intellectually refined studies of the West’s best minds. Peter Apian’s gift to the Emperor: his *Astronomicum caesareum*, for all its pedagogic creativity, colorful illustration, and all its reliance upon mathematical reasoning, functioned just as well as a guide to astrologers as did Claudius Ptolemy’s *Almagest*.

Apian was among the most influential of the army of those who were at that time astrologically inclined. This group included doctors of medicine who studied astrology as part of a normal medical education in the continent’s universities, like Gerolamo Cardano, author of the influential mathematical text, *Ares magna*, and Luca Guárico, court mathematician to Catherine de Medici, both of whom cast horoscopes as a means of increasing their incomes, and Popes, kings and princes, who, regardless of their varying

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willingness to actually take the advice of their court astrologers, understood the wisdom
of having them around and paying them for their services.

While the discussion found in this thesis must stay focused on the areas of interest
delineated in the first chapter of this study, the lives and thoughts of those whose work
we now see as seminal to the conception of modern science, it is essential to note that the
art (and science) of astrology was inextricably intertwined with mathematics, medicine,
cosmology, and so tied to disciplines we all agree today to accept as scientifically
grounded. For many, the planets’ motions, comets’ arrivals and departures, and
especially, the new star of 1572, were of interest precisely because they must certainly
herald as of yet unknown events destined to take place on Earth. Virtually every
contemporary text on the nova I have examined contained some prognostication or
astrological commentary; sometimes these took up the majority of their contents. It is not
out of place to imagine that, for every written record we have of the nova’s appearance,
we are missing possibly hundreds of prognostications written by less famous, less literary
and less educated astrologers, doctors, publishers and fakes.

Though probably not supporting the same level of activity as did astrology, the
middle decades of sixteenth century saw another development that bore great influence
upon the thoughts and perspectives of the students of nature and the heavens: the growing
fascination with geography and cartography that flourished among educated and non-
university trained people alike. Certainly this interest stemmed from, among other causes,
the ongoing voyages of discovery; the growth of the arts and sciences of exploration had
a direct and powerful effect on the science of astronomy as well as an easily discernable
influence on the technologies and industries that surrounded and supported them.
Those who profitably made, printed and sold new maps of the world understood well the gain in making maps of the heavens. Instruments commonly manufactured in the sixteenth century, designed for navigation or cartography, often functioned just as effectively as (and had designs that were often derived from) astronomical tools. The creation of the modern discipline of surveying stems from this period; mathematicians, who certainly had a deep interest in the science of astronomy learned to apply the laws of geometry and trigonometry to the accurate mensuration of land forms. These new instruments occasionally had a second, perhaps less utilitarian, but equally important function: maps, globes, tools and instruments functioned as works of art. The most expensive of these often were traded as gifts, or displayed before the wealthy and powerful. In this way their inherent didactic and scientific purposes would be complimented by their aesthetic charm; the obvious monetary value of the more finely handcrafted advertising their owner’s sense of pride and status. The possessor of a richly engraved and accurately marked celestial globe, whether burgher or court official, displayed not only his wealth, but also his dedication to learning and his desire for knowledge of the workings of nature. While the value of these possessions as works of art is obvious, it seems reasonable to assume that their owners could be expected to take even the most expensive out into the night sky from time to time, and give them a try.

117. See examples of instruments found in the paintings entitled “The Ambassadors” (1533) and “Nicholas Kratzer” (1528) both by Hans Holbein the Younger, in John North, The Ambassador’s Secret, (London: Orion House, 2004); also: Gerard L’E Turner, Elizabethan Instrument Makers, (Oxford: Oxford University Press, 2000).
It is not difficult to find the artifacts left by instrument makers and craftsmen, and thus to discover the trade routes and connections instrument makers and cartographers employed in their dealings with consumers of their wares: astronomers, scholars, doctors and publishers. In following some of these their travels, we can still better detect the outlines of the artistic, technical and intellectual world they inhabited. Almost as an aside to the great story of the publication of the *De revolutionibus*, for instance, one hears of the travels of Copernicus’ student and amanuensis Joachim Rheticus. His itinerary in the years surrounding 1543 (and the motivations for his wandering) seem almost invisible in the literature of the subject. Yet his travels are absolutely essential in understanding how and why *De revolutionibus* ever got published. Apparently finding himself, in 1538, on the outs with administration of Wittenberg University, where he held the post of professor of mathematics, Rheticus decided that this was the time to visit a number of the day’s best known astronomers.\(^{118}\) The list of his stops is instructive. First traveling to Nuremburg, he met Johann Schöner, an astronomer, well known manufacturer of globes, and publisher of Regiomontanus’ seminal work on trigonometry *De triangulis omnimodis*. He became an acquaintance and correspondent of Johannes Petreius, publisher of works by Luther, Erasmus, Melanchthon and Henry VIII. There he also met the mathematician and instrument maker George Hartmann, to whom he would come to dedicate Copernicus’ book on triangles.

Continuing southwards, he came to Ingostadt, where he met Peter Apian, by then famous as a professor of mathematics, cosmographer, and author of *Astronomicum*

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caesareum. Southward yet again, in the spring of 1539, he found himself in Tübingen, where he was introduced to Joachim Camerarius, an educator and humanist whose son, thirty three years later, would observe the nova in Cassiopeia. In this first, seven month leg of his tour, before he began his more famous journey to Frömbork later that very year, Rheticus had met many of the most talented and energetic astronomers, instrument makers and mathematicians of his times. They were undoubtedly influential in his development as a cosmographer and trigonometer. Of equal importance, these Nuremberg connections were to become essential in the publication of *De revolutionibus*. Without these men, Rheticus might have found it impossible to have had the book published at all.

As poorly documented as these peregrinations might be for others we might be interested in, they were a large part of the professional lives of any natural philosopher living in the sixteenth century. As such they must be considered an essential element in understanding the motivations of authors, craftsmen and artists; the sense of wonder and awe that nature engendered in the minds of those involved in its mysteries that made them seek out those of like interests. What tied a Calvinist instrument maker in the Louvain to a Jesuit scholar in Rome, or a Lutheran scholar to a Catholic canon, more than anything else, was the Renaissance curiosity about nature, its apparent secrets, and its power, in all its manifestations. This curiosity and wonder is revealed perhaps in no better way than in the strenuous efforts made by natural philosophers to seek out each other, even if this meant lengthy periods away from home, on dangerous roads, all the while depending upon the company of otherwise total strangers.

119. *Ibid.:* 37, in 1534 Apian published the first trigonometric sine tables calculated to one minute of arc.
To come across a well-traveled path between people who, at first glance would seem not to hold so much of a common interest in the subject of astronomy, should not therefore, cause too much of a surprise as it otherwise might. By way of introducing nova observers to the reader, I would like to describe a number of these “paths,” starting with one of the lesser-known scientific enterprises taking place within one of the better known organizations of early modern European historical study. Catholic leadership had always supported the education of students of natural philosophy. Events within Catholicism in the years surrounding the nova seem to have been fortuitous for the advancement of astronomical study.

Just months before the new star’s arrival, a new Pope, Gregory XIII, was elected to the Holy See of Saint Peter. As the immediate inheritor of the Church’s post-tridentine reform efforts, Gregory is known for, among many things, the committee that gave us our modern calendar (which bears his name), and also, his active interest in cartography. To him must go the credit for a considerable increase in the Vatican’s collections of scientific texts, the construction of the observatory known as the Tower of the Winds, and also, the Hall of Maps, painted by the Dominican monk Ignatio Danti. As Danti’s second patron, Gregory willingly funneled large sums of money into the various projects that marked the Pope as a promoter of natural philosophy and scholar in his own right. Gregory knew he had the right person to carry out those projects because of what he knew of Ignatio’s previous career.

Danti’s work is an especially good example of the age’s confluence of natural philosophical, technological and artistic interests. From a well-known and prosperous family of craftsmen, Ignatio inherited his grandfather’s talents in craftsmanship: Pierre
Vincenzo was a goldsmith; his interests centered on astronomy. What we know of Vincenzo we have from an autobiographical sketch he amended on to his own translation of Sacrobosco’s *De sphaere*. Both Vincenzo’s son, and Ignatio’s uncle worked in the shop of the painter Pietro Perugino. Ignatio’s father and brother became architects, working from time to time for Giorgio Vasari in Florence. It was Vasari who introduced the youngest Danti to the Grand Duke of Tuscany as “the friar for the maps of Ptolemy.”

With the opportunities and connections this family history afforded, Ignatio quickly grew to become a designer and a realizer of the artistic ambitions of the Duke, fortuitously for the history of cosmology named Cosimo de’ Medici.

Cosimo took the import of his given name seriously and saw in it much more than the inspiration for a useful artistic motif. He sought to ensure that the public, his friends, allies and enemies all equated the order of the heavens with the civic order (and dynastic heritage) he seemed ordained to promote and defend here on earth. To this end, he kept both Vasari and his Dominican cosmographer busy with projects like the manufacture of a huge celestial globe that still sits in the *Guarda del la Roba*, Cosimo’s store room of precious objects constructed at the Palazzo Vechio.

A decade before Gregory’s calendar reform, Ignatio was commissioned by Cosimo to build observation equipment that would be used to measure the exact length of the year. The Grand Duke, apparently seeing immortal glory in finding a solution to the ongoing calendar problems of the age, took Danti’s advice and ordered that an armillary sphere be built on the southern façade of Santa Maria Novella. The sphere is still mounted there; it was completed in the spring of 1574, just before the Cosimo’s death.

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Ignatio observed the equinoxes there in 1574 and 1575, these last observations taking place shortly before he was abruptly ordered to leave Florence by Cosimo’s son and heir.\footnote{Ibid., 68.}

After Cosimo’s death, Danti found employment first in Bologna, building solar observatories known as \textit{meridiana} in that city’s churches and cathedrals, then in Rome, painting murals of the most up-to-date maps of Italy and overseeing the construction of the Tower of the Winds: a purpose-built observatory designed to measure the length of the seasons and the year with great accuracy. His work speaks for its creator’s mathematical and architectural skills and knowledge, as well as the Catholic leadership’s interest in new scientific tools and methods of research.

\textbf{Fig. 15: Danti’s Equinoctal ring.}

In Rome, Danti would not have to travel far to find instruction on the latest mathematical and astronomical ideas and tools. Less than a mile from the Vatican, at the
Collegio Romano, the center of Jesuit intellectual life and font of all knowledge taught at the ever expanding network of Jesuit schools across the continent, Danti could have found one of the West’s most talented mathematicians, Christophe Clavius, founder of that order’s school of mathematics. Clavius was best remembered in his lifetime for his commentary on Euclid’s *Geometry*, and also, his oft-edited and published commentary on Johannes Sacrobosco’s *De sphaera*; of which the 1581 version was the first to contain his and others comments on the nova of 1572. Clavius, highly sensitive to the intellectual currents of the age, was very well aware of *De revolutionibus*, and its central ideas, of which he disapproved. No slave to his order’s dogmas, Clavius based his doubts and criticisms upon what he saw as observational realities. He was by no means alone among Catholic clergy in his insistence on the value of observation and mathematics as essential scientific tools. His comments on the nova, brief and belated as they were, point to his grasp of the new mathematics of the age as well as his thorough emersion in the traditions of the Greeks.\(^{122}\)

Made the head of the calendar reform committee by Gregory, Clavius came to occupy a very powerful and visible position within the Church’s intellectual hierarchy. For that reason, he sat at the center of an epistolary network that included many of the great scientists of the age, including his Sicilian colleague Francesco Maurolico, and his correspondent and fellow mathematician Jeronimo Nuñez, who taught at the University of Valencia. There, Muñez held a chair of medicine, which qualified him to teach both astrology and astronomy, as well as Hebrew. One can adduce that he also taught the other

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parts of the quadrivium.¹²³ Not strictly an academic, he was hired by Philip II to survey rivers and determine latitudes of cites in the realm. Nuñez was widely known for his texts on mathematics and the practical art of navigation, but made his greatest reputation with the publication of his 1573 study of the new star: Libro del nuevo cometa.

Francesco Maurolico was a Benedictine monk, professor of mathematics at the University of Messina from his appointment in 1569 until his death in 1576, superintendent of the Sicilian mint and a lifelong and respected astronomical observer, and apparently the first person to record an observation of the nova, in Sicily, on November 6th, 1572. A scholar’s scholar, Francesco wrote extensively on classical and contemporary mathematics, drew maps of Sicily that the Flemish cosmographer Abraham Ortelius included in his groundbreaking Theatrum orbis terrarum.¹²⁴

For all his individual skills and the dedication to observation he is often accredited with, Maurolico cannot be perceived as unique in that, though we know little about his life, through the records of figures like Clavius in his position at the center of a continent wide education system, we can see the reflected thoughts of many such educated and dedicated men of that age. Maurolico’s comments on the nova are of interest to us not only for what they say about the star itself. As Clavius’ trusted colleague, his ideas and opinions came to bear among the greatest of weights for the community of natural philosophers across the continent.

In what we have come to know about the lives of these and others, it is possible to see the outline of a wide-ranging scientifically oriented community within the boundaries

of the Catholic Church. These men had all been educated in the traditional course of studies one might have found at any European university. They came to study the trivium and quadrivium and stayed on to continue their education to the point where they themselves became the bearers, promoters and defenders of the intellectual treasures they had inherited.

Because these scholars had devoted their lives and works to the church, and received all of their livelihoods and funding from its coffers, it might well be assumed that much in the publicly visible output of their intellectual lives depended upon the Church’s priorities. Other people within the hierarchy of Church and Catholic court circles—with or without any noble or otherwise official status—found similar means of paying for research and writing. Peter Apian, at Ingolstadt a generation before the age of the nova was one example of such a person. Becoming an employee of a member of a court was an important way to find income while pursuing one’s career and intellectual interests. Every member of the upper nobility would certainly require the services of a physician for instance. The wealthiest kept doctors of medicine permanently on staff. As in other times, in the later decades of the sixteenth century, it had become the fashion for the wealthy and powerful to keep a court poet, philosopher or mathematician on hand. The mathematically adept; those that entered the ranks of the new field of “mathematical practitioner” functioned as accountants, astrologers and engineers.\textsuperscript{125}

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Chief among nova observers who came to eminence this way were the physicians to the Holy Roman Emperors Maximilian II and later, Rudolph II: Thaddeus Hagecius and Franciscus Covarius. Because of his appointments in the court and government of the emperor, Hagecius also came to occupy the central role of a wide-ranging effort to gather natural knowledge, in purpose and method, not unlike that of Gregory’s. In his case, he became a chief steward and beneficiary of the particular interests of Rudolph, who by many accounts spent far more time and energy building up the inventory of his specimen cabinets (“natural history museum” might be a good modern analogy) than carrying out the tasks of governance required of the Holy Roman Emperor.126

In the later decades of the sixteenth century Rudolph engaged in a creeping withdrawal from his duties as emperor and court social life and was eventually deposed by his brother, seen by most as having lost his sanity. Before others could act to remove him from power, however, he had spent decades and large sums of his wealth supporting a broad range of intellectual activities. His interests made his Prague capital the home of scientists like Tycho and Johannes Kepler, John Dee, Covaruis and Hagecius. 127

As court physician Thaddeus had a very active career. He went with the Emperor’s armies on campaign against the Turks. Much like Muñez, his mathematical skills were in demand for very practical endeavors: he was given the task of producing the first mathematically based survey of Prague. He published books on arithmetic as well as astrology and medicine, and most importantly for us, after observing the nova

through the spring and summer of 1573, a short book: the *Dialexis de novae at prius incognitae stella*, that was well received by natural philosophers across the continent. Like his intellectual peers, he also contributed to the extensive, Europe-wide network of correspondence that the nova inspired, some of his letters being published by Tycho in 1602.\(^\text{128}\)

It is from the pages of the *Dialexis* (as in Tycho’s *Progymnasmata*) that we are introduced to a number of other commentators whose opinions would have almost certainly been lost to us otherwise, and in whose work the continent-wide web of communication is well illustrated. Hagecius published whole the works of his better known colleagues, Cornelius Gemma and Geronimo Nuñez. As did Tycho decades later in the *Progymnasmata*, he also noted the opinions of several certainly well-educated but less well-known people. An ambassador, Andreas Nolthius; Elias Camerarius, the son of the man who knew Rheticus, now a doctor of mathematics at Frankfurt; the mechanic and craftsman George Busch: “Civis Erfurdensis”; Theodorus Gramainaius, a professor at Cologne; David Chrytraeus and Cyprian Leovitius, one a Lutheran theologian and the other a professor of mathematics and Astronomy; all had their ideas and comments recorded. Cornellias Frangipanus, an observer living in Verona made comments that Hagecius, for better or worse in the eyes of Frangipanus, felt obliged to respond to in his public remarks. It may well be an indication of the respect that Tycho had for Hagecius that, a quarter of a century later, he parroted the imperial doctor’s opinions, and expanded at great length upon Hagecius’ criticisms.

If the Vatican and the Catholic world in general had a decided interest in the ideological logic of its doctrines, the Lutherans of Wittenberg were no different. Recall that it was as a faculty member of that university that Johannes Rheticus traveled to Frömbork on the shores of the Baltic in 1539 and convinced the Catholic canon there to publish his ideas on the nature of the heavens. Scholarly authority in Wittenberg certainly had made comment on Copernicus’ work, apparently even before it was published, in the form of criticism, found in the *Table Talks*, written by Luther himself.\(^{129}\) There, he accused Copernicus of attempting to distort the foundations of astronomy beyond the point of reason and utility.

In the years after 1543, Lutheran intellectual authority evolved little when it came to the changing terrain of Copernicus’ astronomical theory. Luther’s son-in-law, assistant and pedagogical theorist, Philip Melanchthon, made no effort to moderate official opinion on heliocentricity. For the founding generations, the new cosmology threatened their literal interpretations of the Bible more directly that in seems to have bothered Catholics. This is not to suggest that Protestants turned away from the study of astronomy. The opposite is the case. As was the Catholic Clavius, Melanchthon became the founder of his denomination’s mathematics and science curriculum. Finding inspiration just as much from the *Timaeus* as from the Bible, he actively supported the study of the heavens. Like Plato, he insisted that God had given man sight to see the stars (quoting Genesis 1:14; “let them be for the signs and the seasons, and for day and years”), and thus to discover His providence. Melanchthon, in his commentary on

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Sacrobosco went so far as to suggest that ignoring the study of the heavens denied an act he defined as basic and natural to human beings.130

Phillips’s son-in-law, Caspar Peucer, also an educator and church leader, was actively engaged in the natural philosophical debates and investigations of the age; his comments on the nova were included in Tycho’s collection of correspondence on the new star: lodged in the middle sections of the Progymnasmata.

Peucer continued the Wittenberg astronomical tradition by training Johannes Praetorius in the skills required of an observer. Praetorius moved to Nurnberg in 1555 where he manufactured celestial globes and other astronomical instruments for seven years. In 1571, he was asked to return to Wittenberg to take up that University’s chair of mathematics. It was there that he observed the nova.

Another descendant of the Wittenberg intellectual community, Michael Maestlin, became a well-known professor of mathematics at Tübingen University. His educational efforts bore fruit in the form of his most famous student Johannes Kepler. Maestlin was yet another member of the republic of astronomical letters, and a contributor to his Danish colleague’s Progymnasmata. Having matriculated at Tübingen in 1568, he had finished his Master’s degree studies in 1571 and had begun to teach theology when he became an assistant to Phillip Apian, son of Peter and professor of mathematics there. It was in that capacity that he worked to discover the nova’s position in the heavens.131

Though not attached to Lutheranism *per se*, Cornelius Gemma, the son of Reiner Gemma Frisius, the cartographer, surveyor and trigonometer, made a career of mathematics as had his father by teaching at Louvain. As a university professor, he observed the nova, and rushed to publish his account: *Stella peregrinae*, the account that Hagecius published in his *Dialexis*. In much the same way as did the Catholic Church, Protestant intellectual and doctrinal needs provided tools for scientific research: livelihoods for scholars, libraries and interconnected literary communities, and more intellectual freedom than might be at first apparent to modern readers. Like Catholicism, Protestant natural philosophy instinctually derived its knowledge of the universe from the classical tradition described in the previous chapters. Little friction existed between the two on that score. It is fair to say that uniquely, the nova vexed and astounded its observers agnostically.

Another important dimension of scientific research in the age of the nova is illuminated for us by light the new star cast on the tools available to the nova’s observers. Enough recorded instances have survived for us to see that, at least in the north, universities, as well as harboring and nurturing mathematical and astronomical studies, also became a source of technical knowledge and skills that the age’s instrument makers used to advance their own careers and the quality of their work.132

As I have pointed out, a long tradition of astronomical observational equipment design existed connected to and growing out of the West’s crafts traditions, extending in

132. Southern, Catholic astronomers must certainly have had excellent mechanics and craftsmen to help them. Interestingly, I have found fewer records of them, who they were and how they did what they did.
writing back to Ptolemy, whose *Almagest* contains instructions for building a lunar parallax measuring device and also an armillary sphere. Physical artifacts like the Astrolabe, also dating back to the ancient world, were in common usage in Europe at the time of the nova. Most famously, the English poet Chaucer, author of *The Canterbury Tales*, also wrote an instruction manual on the astrolabe’s use.\textsuperscript{133} Despite this long history, until the middle decades of the fifteenth century, little had changed in the level of technical quality of available instrumentation. Those years saw an explosion of new and innovative instrument designs however. Much might be said of the futility of attempting to make accurate measurements (by modern standards) of stellar positions before the advent of the telescope. But this assumption is in a way misleading. Astronomers worked to find accurate positions of the stars well into the nineteenth century. Then their primary tool was still the use of parallax; now aided by the use of the telescope. The world had to wait until 1838 before observers finally detected the parallax of a star.\textsuperscript{134}

A century before the telescope’s introduction, astronomers in Europe had already embarked upon a program to revise their basic knowledge of the heavens above them. This they hoped to accomplish by producing ever more accurate observations of phenomena like comets, and by replacing the then catastrophically out of date thirteenth century Alphonsine star tables that were still in use in contemporary astronomy. In the process of doing so it quickly had become apparent to observers that in order to improve upon the work of the Castilian philosophers responsible for the tables, Ptolemy’s lists of star positions, from which the Alphonsine tables were derived, needed a fundamental

\textsuperscript{133} Geoffrey Chaucer, *A Treatise on the Astrolabe*, the earliest known technical manual to be written in English, 1391.
\textsuperscript{134} Friedrich Bessel measured the Parallax of 61 Cygni in 1838 at the Konigsborg observatory, he found it to have an arc of .314 seconds.
In direct response to the challenges this presented, some of the natural philosophers discussed here eventually came to design and build far more accurate instrumentation than had ever existed before in the West. Their invention and use represent a leap forward in the accuracy of stellar positional data as well as the understanding of previously immeasurable phenomena like instrument error. The fruits of these first efforts were put to use in the years just prior to the nova’s arrival, and those who had designed and experimented with these tools put them to good use in 1572.

Those who practiced the profession and trade of instrument making and cartography often straddled the boundaries of traditional craftsmanship and academic scholarship (as Joachim Rheticus certainly knew). They used passed down skills and artistic values to create scientific tools that on occasion could function both as a work of the most ornate and aesthetically appealing art, and equally so, as a precise research tool. Some makers felt at home in an academic environment, as scholars, and as craftsmen, whose incomes were derived not from any religiously founded institution, but from profits derived from overseas trading missions and courtly desires for status. Most importantly for this study, the clear popularity of the subject of cosmology turned cartography and astronomy, seen in the rapidly growing demand in books, maps and the services of surveyors, is an example of the extent to which the study of the world, the cosmos as they would have understood it to be, had become widespread in the year of the nova, as a topic of educated discussion, and as a mathematically based science that relied upon observation and accurate measurement.

The school of craftsmanship (as opposed to the school of university trained mathematical practitioners mentioned above) from which grew this level of talent and
skill was at the beginning of the century a sub-trade of navigational aids, clock making, goldsmithing and jewelry manufacture. By the late fifteenth century, several European cities had developed reputations for instrument design and construction, including and especially Antwerp and Nuremberg. Sometime in the course of the 1500s, university-educated practitioners like Johannes Praetorius began to appear in the field. They took advantage of technological developments like metal engraving for printing to create very detailed and accurate mass-produced maps, naval and celestial charts. With the application of trigonometry to surveying by Gemma Frisius in the 1530s a truly accurate science of geodesy was created.

The work of Frisius, himself a University of Louvain doctor of medicine and mathematics, is often seen as the dividing line between traditional map making and modern cartography.\textsuperscript{135} In 1533 he published a description his method of “triangulation” surveying and of a simple surveying device; the basis of those still used today, in his \textit{Libellus de locorum describendorum}. Gemma also is credited for being the first to suggest the use of a clock to discover one’s longitude. As well as producing his own collection of maps, Frisius trained others in the field, including Thomas Gemini, the first to bring the making of such instruments to England, and more famously, Gerard Mercator.

Mercator’s career spans the sixteenth century, his instruments considered among the finest of the age. Astrolabes and celestial globes from his workshop could be found in collections across the continent, along with the maps for which he is better remembered. After 1569, he was lauded as the creator of the cartographic projection that still bears his

\footnote{135. George Kish, “Gemma Frisius,” DSB 5: 349.}
name; or rather, the mathematical system used to create the projection itself. It is an indicator of the disregard for confessional differences held by contemporary astronomers that, in order to curry favor with his master, Gregory XIII, Ignatius Danti presented to the Pope as a gift, an astrolabe manufactured by the Flemish suspected heretic Mercator.  

A measure of the extent of the growth in interest and economic value of cartography in all its manifestations in the years just prior to the nova can be seen in the vast publishing success of the *Theatrum orbis terrarum* of Abraham Ortelius, a resident of Antwerp and friend and colleague of Mercator, whom he called: “the Prince of Modern Geographers.” Ortelius’s book, published in 1570, and quickly reprinted, was an up to the minute collection of maps by other artists, engravers and mapmakers. In its pages, the reader could find, for all practical purposes, the entire world displayed for him or her, as far as anyone had come to assemble all recently discovered land and far beyond the scope of Ptolemy’s geography, heretofore the educated person’s most trusted guide.

Perhaps an even greater contribution to the age of the nova’s ongoing discourse on natural philosophy was in making the book seem like a collective and up to date effort, capable of evolving with the discovery of new information all must have thought imminent. In an addendum, Ortelius listed no less than 87 sources, the vast majority being his contemporaries. He also invited readers to submit entries to later editions, for which he would give due credit. Ortelius certainly knew that he would have no trouble in getting a response; the epistolary evidence of his network shows that he was in regular

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correspondence with cartographers and astronomers from Lisbon to Krakow and numerous cities in between.\textsuperscript{138}

For us however, the most valuable aspect of this call for new cartographic information was that with it, contemporary philosophers of nature declared that authority could no longer rest in the written records of one or two revered and time honored individuals alone, it now must come from the observational consensus of many. It must include up to date reports and those reports must compliment and be complimented by the new mathematical tools and the understanding of their principles.

The extent to which this interest in the technological, practical end of the business of cosmology had spread across national, linguistic and physical borders is illustrated by the spread of the mathematical Renaissance to England, where it flourished in the middle of the sixteenth century. When Gemma Frisius’ student Thomas Gemini arrived in London, in 1544, he found an already thriving interest in the new philosophy. The demand for his skills as an instrument maker quickly grew to match those of his printing business. Gemini began that part of his career in England by plagiarizing the anatomical drawings found in Andreas Vesalius’s \textit{Humani corpus fabrica}, published just the year before. His version was immediately successful and, because he had translated Vesalius’ Latin into English, brought him to the attention of Henry VIII. Gemini became an oft-employed instrument maker to the Tudor court until his death in the 1560s, as well as a nationally recognized publisher of scientific books and maps.\textsuperscript{139}

\textsuperscript{138} \textit{Ibid.}, 220.
Among his customers were a number of English mathematicians, including Leonard and his son Thomas Digges, and John Dee. Leonard was among the first generation of mathematicians to write in the vernacular, thus exposing Englishmen of middle status to the classical mathematical texts that were still the founding documents of the discipline. A list of the contents of his 1555 *Prognostications* is valuable to us in that they show us what mathematicians (at least the Digges’) of the age thought important. As well as containing Leonard’s predictions of the future, a calendar and schedule of tides and planting dates, Digges included detailed instructions for mariners on how to use a cross staff and a description of a (geocentric) world model. He prefaced this with an apology for the use of mathematics, citing Philip Melanchthon and the Catholic philosopher Guido Bonatus as reference for its practical and morally acceptable uses.¹⁴⁰

The following year, he published *Tectonica*, the first detailed account of the new surveying techniques written in English. That book also included instructions for the use of the astronomical cross staff of the type Thomas Digges used to observe the nova. Gemini used the *Tectonica* as vehicle for his own sales, posting an ad on the title page offering to build the instruments found in the book.

Leonard inculcated in his son an interest in the practical uses of mathematics, but Thomas’ first and most important instructor was John Dee, well known to his contemporaries for his interests in astrology and alchemy. After studying at St. John’s College at Cambridge, Dee had traveled to the continent in 1546 and had met both Mercator and Frisius while studying the sciences at the Louvain, and had returned from this first trip abroad in 1548 with a number of observational instruments. In London, Dee

became an author and tutor, most importantly to Thomas after his father’s death, and shared with him his projects and ideas. Both became committed Copernicans.

The younger Digges continued his father’s experimental work, which included studies of artillery trajectories to compliment and expand upon those of the Venetian mathematician Nicolo Tartaglia. In his 1576 *A Perfit Description of Caelesstial Orbes*, which he added to his the latest edition of the *Progostication*, Thomas included a detailed description of the Copernican model of the world, adding the now well known diagram illustrating a possibly infinite universe. Dee traveled to the continent in the 1560’s, visiting—interestingly enough as his confessional claims were at best ambiguous and he was often and publicly accused of being a sorcerer—Rome, Venice and Padua. In Italy he met the most famous of Renaissance mathematical humanists of his age, Federico Commandino in Zurich, and Conrad Gesner, author of the *Historia animalium*.141

Both Dee and Digges were quite active in the give and take, so to speak, of their philosophical milieu. They were intimately connected with events and interested parties on the continent and shared among each other much of the information and experiences they gathered. Both mentioned each other’s ideas and observations in the books they wrote which contained their observations of the new star. Dee’s *Parallaticae commendationia praxeasque* and Digges’ *Alae seu scala mathematicae* came out simultaneously, shortly after the nova’s appearance. In bulk, both works concern themselves with the “method of triangles” that Regiomontanus expounded in his *De triangulis* in the 1470’s, suggesting this use of trigonometry as the best means of locating the new star in the heavens. Though Thomas and Dee both knew perfectly well the value

of writing in English, their books, aimed not so much at their fellow countrymen (as had earlier mathematics and surveying manuals) as the international astronomical community, were published in Latin.142

Two of the nova’s most important observers on the continent for which the *Alae seu scala mathematicae* was written also had been making good use of its instrument manufacturers and mathematical practitioners. One, the elder of the two, Wilhelm, Landgrave of Hesse, had shown a strong and active interest in observational astronomy decades before as a young man. In his later years he became an inspirational figure and a mentor to Tycho Brahe, who is commonly understood to have completed the program of re-observing the heavens that Wilhelm himself had taken part in during the 1550s and 1560s.

Though becoming a practitioner of any science or craft was considered inappropriate for members of the nobility, Wilhelm, like others of his class, seemed to have no problems crossing that social boundary. Inspired by Peter Apian’s *Astronomicum caesereum* as a young man, at the court of Kassel he engaged Rumold Mercator, son of the cartographer, to tutor him in mathematics. Taking his cue from the *volevells* found in the *Astronomicum caesereum*, in 1560, Wilhelm devised a set of circular metal plates that formed the basis for the construction of a celestial clock—one of the most accurate of the age—which became known as the *Wilhelmsuhr*.143

After his inheritance of the title of Landgrave, Wilhelm continued a semiprofessional scientific and technological career. One of his motivations to do so was

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certainly his princely duty and the fashion of the age to present peers with expensive and ornate gifts. As Landgrave of Hesse, he had a well-known reputation for sending ornate, up-to-date and expensive celestial globes to fellow noblemen. His own private collection of instruments was often commented upon among contemporaries, and a destination for traveling scholars and the curious. This was to some extent simply a useful aesthetic manifestation of his greater interest, however; that of furthering the science of astronomy.

In the 1560s, until he became Landgrave in 1567, Wilhelm became actively engaged in his own program of observation, his contribution to creating a new and more accurate star catalog. To this end, in order to create the first such collection of star positions since Ptolemy’s of Hipparchus’ work, he employed an instrument maker named Joost Burgi, and a university trained mathematician named Christophe Rothman. The three may be considered to have constituted an early form of research group, each providing a set of skills required to effectively complete the scientific investigation they had assigned themselves. In the years after the nova had faded from view, Burgi moved on to find work in the court of Rudolf II, Rothman made several journeys to visit Tycho at his observatory on the Island of Hveen. Despite their years of efforts, the Landgrave and his staff never completed their work, measuring the positions of only 179 out the 1032 stars intended.

Before and after the nova’s arrival, Wilhelm was also in contact with the man who would become his intellectual and investigative successor, Tycho Brahe, then a younger contemporary who, much like Wilhelm, chose to ignore the social conventions

of his class and engage in active astronomical research. As I have described above, the nobleman was sent off to the University of Copenhagen in 1559; expected to study the trivium in preparation for a career as a court advisor, and quickly fell in instead with the mathematically centered quadrivium. Before he left, in 1562—ostensibly to study law at Leipzig—he had acquired copies of De sphaere, Apian’s Cosmographia, and, from his classmate and life-long friend Johannes Pratensis, a familiarity with Ptolemy’s Almagest.\textsuperscript{145}

At Leipzig Brahe continued to show more concern with astronomy than legal studies. Despite the explicit orders given to his tutor Anders Vedel by Tycho’s uncle and guardian, Jorgen Brahe, Tycho smuggled scientific texts into his quarters to read late at night. In the spring of 1563, we know that Brahe was observing the positions of the stars, using only a set of calipers of his own manufacture. In that year, there was a conjunction of Jupiter and Saturn. As the two planets came so close as to seem to touch, Tycho recorded their positions as best he could given the instruments at hand. More upsetting to him than imprecise observational methods he employed was the fact that, according to the Alphonsine tables, the conjunction itself was a month off. Erasmus Reinhold’s De revolutionibus-derived Prutenic tables had missed by only a few days.

Still not finishing any formal education that might aid in bestowing upon him the title of king’s counselor, Brahe traveled to Wittenberg in 1565, after the death of his father Jorgen Brahe. There he took up the sciences again, studying under Caspar Peucer.

The next several years were spent at the Universities of Rostock and Basel, and amid the intellectual communities in a number of towns across Germany. In his travels, Tycho made time to record stellar observations, forming connections with local observers who had instruments to share. In Augsburg, in 1569, he met Johan Hainzel, an avid astronomer himself and a political figure in that city, for whom he designed and built a (huge for the day) nineteen-foot wooden quadrant. Brahe continued to keep in contact with Hainzel: in the spring of 1573, he closely followed Hainzel’s nova observations and later made extensive use of them in his Progymnasmata.

These years of travel around the continent introduced Tycho to many of Europe’s most active and creative astronomers. His part time work as an instrument designer shows him to have been closely involved in the scientific communities of his day. He was well aware of the questions his colleagues were asking and the challenges they saw ahead of them. Having inherited his father’s estate in May 1571, he returned to Denmark. There he continued his mechanical and observational studies, designed newer and larger instruments and kept up the correspondence network he had developed while away, until the evening of the 11th of November, 1572, when, leaving his alchemical laboratory for the night, he looked up into the heavens and saw the new star.

Modern writers of the history of science since long before J.L.E. Dreyer wrote about Tycho’s youth, have understood the necessity of describing the external influences which came to bear upon any individual on whom they focused, no matter how isolated.

146. Dreyer, Tycho Brahe, see Ch. 2.
their lives and intellectual efforts seem to be. But this can be easier said than done. Discovering and connecting all of the members of the coterie involved in such an effort, as was the gathering and sorting of raw data in the sixteenth century, would be a challenge in itself. Authors doing so would certainly run the risk of distracting the reader from his or her primary concerns and central arguments. Just as importantly, however, if these connections and experiences are not understood in some detail, the reader of any study of the records of the celestial events of 1572, especially those recorded by a strikingly diverse and individualistic group of people like Gemma Frisius, Hagecius, Muñez, Clavius, Hainzel, Wilhelm or Tycho Brahe, as well as many other contemporary natural philosophers, professional and amateur, might not fully grasp the extent to which the program of observing and cataloging the stars, and working to understand the nature of the nova, was part of a larger movement of intellectual inquiry that had spanned the entire sixteenth century.

This cursory overview of the age’s *personae astronomicae et geographicae*, highlighting as I have, their astronomical, literary, instrumental and mathematical activities, allows me to finish making an essential point that I have developed in the preceding chapters: that, by the beginning of the 1570s, virtually every field of natural philosophy that might impinge upon the reception of the nova was in the process of experiencing a fundamental reorientation, from its classically founded, literally oriented traditionalist perspective, to an activist, observationally based, rapidly mutating, collective enterprise, which now was better described as falling under the broader heading of cosmography than that of astronomy alone. While relying upon and respecting their intellectual inheritance, observers of the world in 1572 also listened to new opinions.
about things, sought out new information from far off places; they readily sought out the use of new tools and methods to aid in their investigations. Almost every person I have come across in my researches had not one but two or three professional sidelines. They were scholars and surveyors, and astrologers, and doctors and authors. They worked hard to make connections between varying disciplines and disparate events taking place in the world around them.

Through the end of the sixteenth century, the work of philosophy continued to be primarily a matter of debate; the age’s cosmographers opened up that dialog to include virtually everyone with some skill or idea or new found fact that could add to their evolving body of knowledge. Jesuit astronomers, Flemish cartographers, German instrument makers and English mathematical practitioners all had something of value to add, and something to say. By all accounts, the literary republic of natural philosophy listened to, amplified, and elaborated upon and transmitted their ideas.

To understand why someone like Tycho (who preserved for us the thoughts of many of the people I have mentioned here who saw the nova) or any of his contemporaries could take such interest in the new star—with his colleagues, a more active interest than that taken by those living and observing the heavens in previous ages certainly—it has been necessary to note that the world they were raised into was defying the traditional means of gathering knowledge and deciding what was of value. The nova’s observers understood the value of the new sciences with which they were beginning to experiment. They shared a common interest in their methods and their tools, even if, it can be argued, they shared no new formal philosophical doctrine on which to base their methodology.
In ending this chapter, I think that it is most valuable to emphasize one last time that, in the 1570s, natural philosophers also understood the power of the new mathematics to define and describe that world, and had faith in its veracity, even if they did not have the most effective physical tools at hand to pursue its use, and had not had much luck in the heavens so far. The age had been graced by a parade of comets. Astronomers had aimed their instruments skywards, struggled to determine their true locations, and had come to no real conclusions about where they were in the universe. Yet for all the failures on this front, through the 1560s each time a new comet appeared, they went out into the night sky with their cross staffs and astrolabes to see what might be measured and discovered.

Further, the intellectual methods astronomers were to employ in their analysis of the observations of the nova were far more straightforward and simpler than those theoretical devices found in the *Almagest* and the *De revolutionibus*. They were not at all ineffective however, and those tools and methods they did possess gave them this advantage: in 1543 Copernicus wrote in his introduction to the *De revolutionibus* that his work was best left to the mathematicians who could understand the complex and abstruse ideas he used numbers and geometric shapes to illustrate.\(^{148}\) This was at best a limited group. The written artifacts of the arrival of the nova prove that many more natural philosophers had some idea of the means by which mathematics could be used to answer their questions, and they were already practicing with a far larger array of instruments and techniques with which to measure the natural world around them than, it might be sometimes implied, they could. By the 1560s these tools had grown in accuracy and

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148. See footnote 77, above.
versatility; they made mathematical analysis easier and more accurate. When the time came, they were readily turned towards the new star in the heavens.
Chapter Five
The Reasoned Response: What its First Observers Made of the New Star

...A miracle indeed, the greatest of all that have occurred in the whole range of nature since the beginning of the world...For all the philosophers agree, and the facts clearly prove it to be the case, that in the ethereal region of the celestial world no change, in the way either of generation or corruption can occur, takes place; but that the heavens and the celestial bodies in the heavens are without increase...undergo no alteration...that they always remain the same. Furthermore, the observations of all the founders of the science, made some thousands of years ago, testify that all the stars have always remained the same number, position, order, motion and size as they are found...

Tycho Brahe, 1573

The heavens, on any clear night before the invention of the electric light, were filled with far more than the official (i.e.: Ptolemaic) 1022 stars that made up the canonical catalog of the inhabitants of the eight sphere in the sixteenth century. That an educated observer living in the centuries before the invention of the telescope might be led to believe that there was some finite number at all, and that that number was so obviously incorrect, is indicative of the nature of the central crisis that astronomy in the age of the nova faced: to accept the reports of the ancients was to accept the veracity of what was demonstrably wrong. Long before the new star arrived astronomers had begun to lose faith in the great tradition of their classical astronomical heritage. But just what was amiss was hard to say. Had the great classical natural philosophers been so wrong in their assumptions and claims about the celestial realm? Was there something wrong with

how people, then and in 1572, saw things in the skies, or in how they, ancient and contemporary alike, understood what they saw?

Mentioning this dilemma is a good way to bring up the issue of observational and theoretical challenges that any serious astronomer faced when confronted with such a daunting set of contradictions that the nova presented. One modern author, who had certainly spent much time studying the millennial-long records of human astronomical observation, countered the suggestion that Western observers had ignored new stars by arguing that the appearance of novae would be masked by the lights of their millions of neighbors; they were inconspicuous and temporary flashes drowned out by the thousands upon thousands of similar objects surrounding them. Given their rarity, observers simply might never have seen them in the first place. The author, who made the comment in the course of examining Asian records of reported celestial anomalies, perhaps didn’t grasp that Asian observers, who had no trouble catching sight of—literally—hundreds of transient celestial phenomena throughout their several thousand year history of recorded observation, after all had the same equipment as did their counterparts in Europe: their vision.150

It is safe to suggest that, perhaps, the new star of 1572 was more attention-grabbing than previous guest stars. To be fair, it was initially visible during the day, when little else on a clear afternoon might distract the wandering eye. For whatever else might have colored the perspectives of celestial observers in the West in previous centuries, the nova of 1572 made itself unavoidably apparent to those on the earth below.

Though our records of the first sightings sometimes come from accounts published years and even decades after the nova disappeared from view, the circumstances surrounding these observations, and how they came to be reported to contemporaries, are a valuable addition to the story and leave us with an interesting impression about the age’s star watching habits, the thoughts and concerns of academic and courtly society surrounding individual astronomers.

At the very same moments that they were craning their necks upwards, nova observers were putting their thoughts, impressions and ideas on paper, passing them on to friends, or posting them across the continent. Occasionally, in the immediacy of the moment, the new star’s recorders wandered beyond the immediate bounds of their subject matter to let slip some comment that can be helpful to use in determining what others thought of the visitor. Brahe’s later statement, that “sailors, carters and herdsmen” were better at observing the nova then his fellow professional astronomers, is a good example.\footnote{Dreyer, \textit{Tycho Brahe}: 188.} One gathers from such off hand comments that the non-scientifically inclined citizens of courts, cities, towns and fields across Europe were all witness to the new star’s appearance; all might have voiced their opinions and their concerns over the new star. To what extent we are able gather any information about the actions and opinions of those outside the immediate astronomical community we are interested in varies from author to author, but occasionally we have some luck. A paragraph here or a sentence there provides us with a view into the minds of those groups and individuals who constituted the social milieu of our subject observers.
Recorded first sightings by professional astronomers more or less ensure that the modern student can place its arrival time at the beginning of November. Quite independently of others in their field (who would have, after all, been a long way off in terms of the speed that news in those days traveled) dozens of astronomers—professional and amateur—across the continent caught sight of the new star within weeks and even days of each other; a testament to the dedication and activity people of all stations put into the art of sky watching. At Valencia, Heronimo Muñez was sure he did not see the star on November 2nd, the night he spent showing his students the stars in Cassiopeia. In Sicily, Fra Maurolico noticed the star on November 6th, the same day as did his counterpart at Wittenberg, Wolfgang Schuler. Paul Hainzel for whom Brahe had made the now famous nineteen foot quadrant saw it on the following night, as did the Swiss minister Bernard Lindauer. Tycho, himself, at Heridsvad, first saw the star on November 11th. Wilhelm IV at Cassel saw the nova on December 3rd.152

Wilhelm, his reputation as an astronomer (and astronomical gift giver) then wide spread, immediately received letters of inquiry from courts around Germany. Albert, Duke of Saxony, the patron of Erasmus Reinhold Junior, son of the author of the Prutenic Tables and no mean observer himself, the Princes of Braunschweig, the Palatinate and Wurttemberg all sought his opinions. No less than the highest levels of court officialdom were having their concerns.153

Muñez did not see the nova for himself at first. Interestingly, he reported in his book that - in rather biblical fashion - shepherds came to him to tell him of the new star they had discovered. He noted in his introductory comments to the Libro de la cometa,

152. Ibid., 62.
that he produced his short book at the request of Phillip II, in part in order to calm the
court which he notes “was in an atmosphere of suspense” over the arrival of the star.\textsuperscript{154}
What common opinion made the object to be is indicated by the fact that he himself
called it a “cometa” in the tile of his book.

His colleague in Rome, Christophe Clavius, almost certainly a regular observer of
celestial events, deferred his opinions of the nova to those of the Dominican scholar
Francesco Maurolico because he knew that the Sicilian was an adept, lifelong astronomer
and therefore someone whose opinion was more valuable than the “multitudes who have
voiced their thoughts with little or no knowledge of the subject.”\textsuperscript{155} Clavius himself did
not publish an independent work, instead including the Sicilian’s comments, along with
his own introduction, in his 1581 commentary on Sacrobosco’s \textit{De sphere}. Until recently,
this was the only source of Maurolico’s comments modern scholars were aware of.\textsuperscript{156}

Tycho Brahe; even at this very early stage of his career almost certainly a more
seasoned observer than most European professionals, claimed to have seen it first among
his educated colleagues, but not his fellow Danes. He recorded that, leaving his
alchemical laboratory on the evening of November 11\textsuperscript{th} he looked up into the clear night
sky to see a bright star he had never observed before. Somewhat disconcerted, and sure
that heretofore nothing had been in the position of the new star, he called his servants out
to confirm what he observed, which they all did.\textsuperscript{157} Still not completely satisfied with his

\begin{flushright}
156. His original comments were first published by C. Doris Hellman, in 1966, \textit{Isis}, 51 (3) 322 – 336: “Maurolico’s “Lost” Essay on the New Star of 1572.”
\end{flushright}
own visual experience, he turned to a nearby group of peasants, who concurred with his servants – peasant’s eyes, it turns out, being just as good as his own.

The following January, in Copenhagen having dinner with a friend and fellow astronomer, Johannes Pratensis, Tycho mentioned the nova and to his surprise, found that no one else at the table had seen it. Pratensis, records Brahe, thought he was joking. Their dining partner Charles Dancey, french envoy to the Danish court, went so far as to suggest that Tycho was a bad observer. The evening sky was obliging, and they were able to see Cassiopeia and its addition quite clearly, much to the shock of their host and the satisfaction of Brahe.¹⁵⁸

For his part, Tycho let out his frustration with the “many accounts of the new star…containing a vast amount of nonsense”¹⁵⁹ in his Nova stella, published, so he claimed, to combat public calamity. With the onset of spring and the restoration of communications with Germany, he was bombarded with a large number of less than thoughtful accounts of the nova’s arrival, most it seems, concluding that the mysterious object was in fact a comet, or some new and unidentifiable thing far below the moon’s orbit.

It is perhaps because of what he considered to be his colleagues and fellow astronomer’s overly exited reactions that he published his very minimal and sober depiction of the star in his account of the new star (see page 35). In decided contrast to other’s illustrations, his is plain; unadorned with guiding images of mythological figures and any of the gratuitous collection of human figures and animals that usually bordered

¹⁵⁸. Dreyer, Tycho Brahe: 42.
¹⁵⁹. Ibid.: 43.
or filled contemporary pictures of the constellations. Any hint of the outline of the nova’s neighboring Cassiopeia is missing; something easy to illustrate and certainly utilitarian.

As far as I can discover, the only versions of letters and notes making the star out to be someplace it was not or seeming to be something it plainly wasn’t, to have survived anywhere are a very few of the letters and accounts included in Brahe’s *Progymnasmata*, for which, on occasion, Brahe had reserved a special venting of his spleen. Most unfortunate of the nova’s less than accurate recorders was Hanibal Raimundus Veronensis, an Italian scholar who claimed to have seen the star first, in early October; a full month before anyone else. Raimundus’ case was not helped by the fact that, in November no less, he had been one of the observers that mistook one of the stars in the constellation Cassiopeia for the new star, missing its dimmer but still visible close neighbor the nova altogether.

The Dane’s report quickly summed up his opinion of Raimundus’ work as being: “incompetent, insolent and deprived of reason, its author presumptuous, arrogant and audacious.” 160 Italy had produced many great scholars he was at pains to note, and Raimundus had in the past showed his intellectual talents in other areas, so how had he produced such an inept work? At the beginning of October, noted Tycho, “many noble, non-noble, erudite and non-educated people” with their own eyes would have seen the nova. In Germany, he was willing to grant, perhaps being further north, people did not notice it. Muñez in Valencia certainly had not either however, perhaps – noted the Dane - the air was somehow different in Spain? 161

Raimundus was by no means the only nova observer to see something that seemed not to be there. George Busch, in Ehrfurt, had his publisher create an elaborate wood block print showing the nova, complete with appropriate mythological figures. The nova, interestingly, is not only labeled a comet, it is depicted as having a tail, or tails, an phenomena that was not reproduced on any other surviving work, and assuming the artist was indeed looking at the nova, not there in the first place.

Though he was ill in the first weeks of the nova’s appearance, Thomas Digges was commissioned to report to Elizabeth by her principal secretary, councilor and confidant, and his patron, Francis Walsingham. The report was to end up as part of a small international dust-up. Almost certainly the first among authors to publicly comment about the star was the librarian to the king of France Jean Goselin. Before the month of December was out, he had his pamphlet *La Decleration d’un comete ou estoille prodigieuse* in circulation. The short work had just a few pages of observational data followed by a final page of verse discussing the celestial theories of Manilius and Aristotle. As with many others, Goselin immediately attempted to find its position using the new trigonometry. What ever his level of mathematical skills were, he seems to have had little practice as an observer.

The French capitol, where Goselin lived and worked, had played center stage through the previous decade’s on again off again civil wars. English ambassador Thomas Smith, sensitive to the unsteady political and civic climate of the city, and sensing the tremors the nova’s arrival sent through French political society, sent a copy of Goselin’s work to London to have it looked over. Few in England knew what to make of it and

needless to say it quickly made its way into the hands of Digges. Before he had the time
to publish his *Alea seu scala mathematicae* he wrote a quick, anonymous letter to Smith
which got out into the wider public of the French court. Digges was more than a little
critical of Goselin’s findings: he contended that Goselin’s parallactic measurements put
the star only about one quarter of the way to the moon, where it clearly was not, and
quickly concluded that the heart of the problem was that French (read Catholic?)
astronomy was entirely inadequate to the task at hand.

Curiously, Cornelius Gemma, a professor of mathematics at Louvain and son of
Reiner Gemma Frisius, a respected astronomer himself who had revolutionized geodesy
and cosmology, didn’t go look at the star until November 26th. Though advised of its
appearance on November 9th, he simply refused to believe what he was told.163 Upon his
finally bothering to look upwards, he quickly changed his stance, publishing one of the
earlier accounts of the new phenomena: *Stella perigrinae iam primum exortae et coelo
constanter laerentis Φκένόµενον vel observarum*. This report was in turn quickly
translated into other languages, and saw at least four different publications throughout
1573. It also found its way into the books of the continent’s authorities; being appended
to Hagecius’ *Dialexis* and to works by Guilliam Postel and Cyprian Lewovitz.164

Gemma’s observations and comments were taken with great seriousness by the
imperial doctor, a measure of the wide respect that the well known son of the
mathematician and cartographer Reiner had garnered in the years he had spent on the
other side of the continent, theologically as well as geographically, at the Louvain.

163. Cornelius Gemma, *Stella perigrinae iam primum exortae et coelo constanter…*” first published in late
December 1572, and had four printings in less than a year. *De naturae divinis characterismis*, 1575,
volume II mentions his experience with the nova.
164. Thaddeus Hagecius, *Dialexis de nova et prius incognitae stella*. See appendix B.
Hagecius included his observations and calculations in the first chapter of his *Dialexis*: that reserved for his and other’s mathematical measurements; there one also finds Paul Fabricius (a fellow physician to the Emperor), and Hieronymus Muñez, himself working for the other Hapsburg, Phillip II, in Spain. That the emperor’s physician included the work of these individuals is a good measure of the worth he placed in their talents and their thoughts.

Hagecius’ concern for these observers’ records, while possibly derived from their recorder’s status at court, might also be accounted for by the fact that the two had compiled detailed collections of numerical values for the star’s position. The potential importance of these records to his contemporary readers was made clear by Hagecius when he prefaced his commentary by noting that, in comparison to his colleagues, the canonical list of stellar positions: “Que enim de hoc hodie habemus, ex Ptolemo & Alphonso, emendatione egent, ob errores plurimos, qui vitio scriptorum, & diuturnitate temporis paulatim irrepserit”\(^{165}\) (“What indeed today we have from Ptolemy and Alphonsus, requires corrections on account of the scribes many errors which make their writing faulty and for a long time have gradually been insinuated”). Hagecius wasn’t going to spend much time relying on the so obviously faulty information of the ancients.

This is not to say that the emperor’s physician was in agreement with the information his colleagues had proffered. Not one to pull punches, the author repeatedly and summarily declared their results inferior to his own. Still, Gemma, Muñez and Fabricius all got generous kudos for their efforts; to hear Hagecius tell it, he would have

\(^{165}\text{*Ibid.*, 14.}
simply been unable to conclude his own work without the efforts of these august individuals.

Not so lucky were the philosophers and their opinions, to which he turned in the next chapter. Why exactly Hannibal Raimundus, the Veronese philosopher whom Tycho had criticized, and Cornelius Frangipanus were both singled out for attention is not clear (and such lengthy attention at that); it might not be too far beyond the bounds of reason to assume that Hagecius had dealings with either or both in the past.\(^{166}\) Frangipanus got the least bruising from the author, who dismissed his quantitative results out of hand, noting that he had completely misplaced the star in the wrong side of the heavens in the first place.\(^{167}\) Hagecius denied his conclusion that the nova’s light came from its proximity to the moon, which was often found on the opposite side of the sky, or for that matter from time to time not found at all.

As had Tycho, the imperial doctor had much more to say concerning Raimundus’ ideas, using the same criticisms as had the Dane to systematically debunk his theories point by point. Postulating that it had been there all along, and somehow greatly increased its brightness since its first appearance was one thing. Tycho himself did not completely oppose that idea. There was the problem of chronology however. How, asked Hagecius, had the Veronese doctor possibly mistaken the nova for another star, or seen the nova a full month in advance of everyone else? In order to ensure that the reading public fully understood where he was coming from, so to speak, the author posted scholia along the margins of the pages which contained his comments on Raimundus’ observations and conclusions, noting succinctly: “Raimundus malus Logicus, & ineptus

\(^{166}\) Dreyer, *Tycho Brahe*; 64; the author suggests as much.
\(^{167}\) Hagecius, *Dialexis*; 28.
Astronomicus,” and “Raimundus Ignorata.” With hind sight, I think it is safe to say that one might want to think twice before disagreeing with the emperor’s physician.

The nova, for all the commentary (polite or otherwise) that it did generate, presents a much more pointed and perhaps telling mystery than those found in the accounts and thoughts of its published observers. Present at the time of its appearance was one of the most active, talented and perceptive astronomers of the age, Ignatio Danti. The Dominican friar stood as one of the most recognized mathematicians and cartographers of his age. He was widely respected for his knowledge of the works of Ptolemy, and for his several texts on mathematics, and on mathematical instruments. In 1572, he was actively involved in no less an assignment than measuring the exact length of the year for his patron Duke Cosimo I in Florence, a task that would only be assigned to a publicly recognized professional astronomer.

It would not seem to be too unreasonable for the modern reader therefore, to expected to find much of interest about the nova somewhere in one or the other of the two textbooks on mathematics and astronomy he had written and published while the nova was still in the sky above him. In 1573 Danti published La sfera di Proclo Liceo, tradotta da Maestro Egnatio Danti, and La prospettiva di Euclide: nella quale si tratta di quelle cose… The several hundred pages that make up the combined lengths of both these works traverse the entire spectrum of physical science as it was understood in that year. Danti showed himself to be more than familiar with the mathematics of the day. He rehearsed for his reader the contents of the heavens, their immutability, their motion and,

168. In 1569 Danti had published a text on the astrolabe: “Trattato Dell Uso et Della Fabrica Del Astrolabio.”
169. Both published in 1573, see especially La Sfera, see introduction (penned in October, 1573) and Ch. 1.
as with all other astronomical writers of the age, their grandeur. He listed cities and nations; their latitude and longitude and how to find them, all the while taking care to quote authorities such as Aratus, Manilius, Macrobius, Albertus Magnus, Sacrobosco and others. Neither of these books contains a word about the nova.

To judge from the ubiquity of its mention in the works we have, the first mystery the nova presented to its observers, and the most important question all (who left the records we are interested in) seemed to ask immediately and independently of each other, reflected directly backwards. It pointed towards the basic assumptions about the nature of the universe they were taught in the courses of their educations that I have discussed in previous chapters, and those that the star’s presence threatened. This was a deceptively simple question: where was the star located?

Once it was accepted that there was in fact something there, almost all serious commentators whose writings have survived to our day immediately understood this most fundamental discomfort the stranger’s appearance provoked. Virtually all the sources that come to us describe the author’s efforts to figure out whether or not the star (if indeed that’s what it was) was beyond the Moon or below the celestial sphere the Moon inhabited. Was it in the changeless realm of the quintessence, embedded in the perfect, incorruptible and immutable realm of the heavenly spheres? Could it be, alternatively, below the sphere of our nearest neighbor, and therefore in the realm of the corruptible, changing universe: as far as current theory went, a far safer place for it to be? The 2000-year-old physics of the ancient Greeks, so often rehearsed over the intellectual lives of the star’s observers, and still very much the respected bedrock of European’s
understanding of the world, had naturally provided the immediate logical framework upon which all discussion must take place.\textsuperscript{170}

For all the efforts made to improve the theory and technology of mensuration the previous decades had witnessed, advances that the nova’s observers like Wilhelm and Tycho had at their disposal, many, perhaps most, fell back upon some of the oldest and simplest means to gather information about the mysterious guest. The new star’s arrival predated the development of the telescope by some thirty-six years. But neither Galileo’s best device, nor Isaac Newton’s would have been of much value. What data modern scientists can glean from such events requires radio telescopes, or perhaps instruments in orbit, or the most powerful modern optical telescopes sitting atop mountains in Chile and Hawaii. For what mysteries its observers would come to see in the new star, for what questions they felt compelled to ask, these sorts of instruments were not necessary, however.\textsuperscript{171}

To answer the question of the star’s location, virtually all resorted to a simple idea discussed in the Almagest. To try to discover the new star’s location, the entire profession seems to have turned to the method of parallax described by Claudius Ptolemy fourteen hundred years before, and expanded upon, more recently for nova observers, by Peter Apian in the oft reprinted Astronomicae liber, and by Regiomontanus in his posthumously published De trianguis omnimodis of 1533.\textsuperscript{172}

In reality, there are several methods of measuring parallax, and I shall describe in more detail those ways understood by the nova’s contemporaries in the next chapter. For

\textsuperscript{170} I remind the reader to consider Aristotle, Physics 265 a16 to a 20, and On the Heavens, 269 and 270. 
\textsuperscript{172} Claudius Ptolemy, Almagest: 243. See also Regiomonatus’ De cometae, 1531.
now it is important to say just that the concept of parallax was fairly straight forward, easy to grasp using the intellectual means of the day and, given some patience and skill, anyone familiar with a few simple ideas might be capable of developing a good guess as to how far away objects like the Moon were from the Earth. The Moon’s parallax in relation to the fixed stars could be measured to be as much as a few minutes of arc—a minuscule distance, but well inside the boundaries delimited by man’s sight—without the aid of a telescope.

Anything beyond the Moon would of necessity display a smaller parallactic angle. Since the Moon’s sphere marked the boundary between the corruptible world below and the unchanging world above, any object, such as the Sun, the stars and the planets, that seemed to measure a smaller angle, was bound to reside in and be made up of the matter found in the celestial realm. To jump ahead a bit; no parallax had ever been measured from any other object other than the Moon, so everything seen in the heavens other than comets, and the nebulous Milky Way, both of which Aristotle had in any case put in the sub-lunar region, were traditionally taken to be more distant from us than our satellite neighbor.

If one sought only the relative distances between celestial objects, rather than absolute numerical values, no more was needed than any simple (but as finely made as possible) measuring device like those illustrated in appendix A. With this they might determine the Moon’s parallactic angle. If the observer sought to derive some numerical value for the distance of this star (as some did), he or she would also need before-hand a guess as to the size of the Earth and its distance to the Moon. On a grander scale this quantity was valuable because it could, through the use of the tools of classical geometry,
produce some ratio of size to distance between the celestial object and earth, and therefore, ultimately, the distance to the final crystalline sphere that marked the

Fig. 16: Standard depiction of the geometry of Parallax, from a medieval text. This drawing can be found as well in many sixteenth century texts, including Tycho’s Nova Stella, on the right. The earth is the central circle, the celestial sphere the outermost. The point where the two lines converge on middle circle denotes where the object to be measured was located.

boundary of God’s creation. Long before Ptolemy, Greek natural philosophers had sought that numerical value, and had come up with several good guesses. Most famous of these was that of Eratosthenes, who worked in Alexandria in the middle of the third century B.C.E. The estimates of Eratosthenes, Strabo and others were certainly well known to

sixteenth century cosmographers, geographers and mathematicians; they were time
honored elements of the classical canon.

Contemporaries of the nova had spent their energies on the same questions
themselves, using the same tools and ideas. As far as the nova’s observers were
concerned, little in the way of “cutting edge” scientific thought would be brought to bear
on that aspect of the new star’s mysteries. While the star remained bright and constant,
this notion of a numerical measure of its distance seemed less important than that of its
place in the universe. As the star dimmed in the months after its first sighting, however,
thoughts about its distance (constant or changing) in some measurable value were bound
to enter the discussion.

The use of the method of parallax, it might seem too obvious to say, required that
the observer place the location of the object in question as accurately as possible against
some external reference: among its neighbors, and/or, in relation to the coordinate system
that was in favor at the time: a sort of grid system created by Ptolemy to match the
system he had described in his Geography to locate places on Earth. To properly locate
the position of any star was no simple task however. Observers knew perfectly well, after
all, that current stellar positional data (which of course did not include the nova), much of
which ultimately came to them from the above-mentioned second century Greek
astronomer in the first place, was far from accurate enough to encourage confidence that
the star could be appropriately placed among its neighbors, or on some grid, and therefore
end doubt about its positional nature. As ambitious as the Landgrave of Hesse-Kassel’s
instrumentation program was, little new data had been published in 1572 that would
encourage confidence in the age’s struggling attempts at accurate measurement. In any
case, few others in his circle or, for that matter, in Europe, could imagine parting with the
cash he had undoubtedly invested in order to produce the finely constructed instruments
at his disposal. Most astronomers in the second half of the sixteenth century who wanted
to make some positional sense of the heavens contented themselves with rulers, cross
staffs, gnomons, the occasional quadrant or astrolabe. Famously, Michael Maestlin, later
the source of inspiration and mentor of no less a figure as Johannes Kepler, reported to
Tycho in a letter that he went out night after night to observer the nova armed with a
piece of string, which he held above him to measure the distances between the nova and
the stars of Cassiopeia.174 Using such a variety of tools, as one well imagines, the results
gathered from observations would vary: from the wildly off, to the astonishingly on.

Another factor to consider when reviewing the first reports is the varying and
accumulated experience of the observers themselves. As one might well imagine, veteran
observers, (such as was Brahe in 1572, at the seasoned age of 26, and Thomas Digges, at
27; often given a close second place behind Brahe for accuracy by modern astronomers)
who had invested both their time and energies in regularly observing the heavens
beforehand, were probably more likely to make better uses of the tools they had on hand
than those who, caught up in the excitement, ran out into the night and attempted to put
theory into practice for the first time, regardless of how good their equipment was.

This was, of course, if the star obliged its viewers by staying around long enough
for them to settle their observational problems and challenges. Taking just one set of
measurements was by and large meaningless; a certain amount of the haste and concern
displayed by observers can be accounted for when one considers that, for all anyone

174. Please do try this at home, I have found it to be astonishingly accurate. See TBOO, vol. III, 64 for
Maestlin’s full report.
knew, the nova might just as well vanish as quickly as it appeared. In order to observe and measure parallax accurately and with confidence in one’s measurements, the astronomer needed to gather information repeatedly, and regularly compare results. This ensured as wide a base of observational data as possible in order to create a more precise set of calculations. Haze, fog, clouds, wind, bright moonlight and shaky hands all threw in their detrimental effects, so experienced astronomers must have counted their blessings every night they had a clear shot. Strictly as luck would have it they ended up being able to watch the star for many months.

For better and worse, Cassiopeia, the constellation in which the star appeared, is fairly far to the north in the sky, and because of this, it does not set for most of the year over much of Europe. The nova’s far northern altitude—Tycho calculated 61 degrees, 47 minutes above the celestial equator—could have been a blessing as well as a curse: on one hand few large and therefore we assume more accurate instruments could be set to measure stars that high in the sky without much twisting and bending, on the other hand observers were free from the atmospheric distortion they knew affected their observations of objects near the horizon. In the next chapter, it will become clear that the star’s high latitude gave the better equipped astronomers this advantage: since it never set, it could pass not once, but twice through an observer’s meridian circle on a given night. This imaginary demarcation crossed through one’s field of vision in just the way one would hope if one were to get the most accurate results from his or her’s observations. And to top off their good fortune, astronomers of the age were well aware that because of the star’s altitude, they were mercifully free of an observational phenomenon called

175. Dreyer, Tycho Brahe: 40. Nicholas Oresme the fourteenth century natural philosopher wrote a treatise on atmospheric distortion: De visione stellarum. Some of Tycho’s later work revolved around coming up with a mathematical relationship between stellar altitude and atmospheric distortion.
“parallactic dip.” Without going into too much detail, it will suffice here to say that any object that is close to the horizon while being observed, will suffer from this distortion, so the higher the better.

In November 1572 no one could know that it would change in the way it would throughout the following year. Almost unanimously, and before its appearance could be telegraphed along the continent-wide epistolary communications web, observers in the late fall and early winter of 1572 pulled out whatever tools they had on hand and tried to determine where the star was in the universe; to try to determine what, if any, parallactic discrepancy might be observed. Tycho, Hagecius, Muñez, and a hundred other astronomers across Europe, professional or otherwise, courtiers, doctors, astrologers, sailors, farmers, townsmen, all spent the winter no doubt anxiously awaiting the next clear night sky that might let them once again see the mysterious star.

As important as was finding the location of the nova, astronomers could not help but note its appearance. The star in Cassiopeia, after all, had hung in the sky for no fewer than fourteen months. In that time, it had not remained constant in color or brightness. It began by shining with a silvery tint, visible even on clear days, then slowly, diminishing into a dim ruddy light before fading out entirely in the winter of 1574. Some who recorded the appearance of the star wrote that, in the spring of 1573 it briefly (for several weeks) flickered and became once again bright white. Not all observers reported these changes however. By the time the star had begun to shift its appearance, faster writers had already published books and reports on the subjects of interest surrounding its arrival.

Only more patient, slow or repeat authors mention these additional mysteries. In his *Progymnasmata*, Tycho was able to dwell at length on the several possible meanings of this shift in appearance, in a way he could not, in his *Stella nova*. He did however, as did all of the observers I have read who published in the immediate aftermath of the nova’s arrival, make much of its “miraculous” brightness, its color, its shimmer and seeming variations throughout the days and nights.

Were the changes the nova underwent evidence that this was not a star in the commonly held sense? After all, the denizens of the eighth sphere, whatever they might be, were changeless and constant. What exactly did its metamorphosis mean? Was it indeed in the realm of the planets rather than the stars? Previously convinced that they had possessed a good idea of what a star was and was not, astronomers were now compelled to try and figure out what had caused its evolving appearances.

One school of thought saw its dimming as proof that the star was moving away from the earth. Far from being tangential to the arguments of the moment, this theory led to its own possibly troubling conclusions. If the star moved away from its observers in a straight line, as it seemed to be doing, it was just as much in violation of any Aristotelian logic in that, by definition, a celestial object, as a sign and proof of its perfection, moved in a circular path. Some authors, like the Frankfurt mathematics professor Elias Camerarius, son of the Camerarius that knew Rheticus in 1539, made the revolutionary charge that it had no less than three motions: circular (as did all objects made up of the changeless fifth element), upward (as did fire and air) and downward (as

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did earth and water).\textsuperscript{179} To this Tycho (who recorded Camerarius’ conclusions) later noted that, according to every account he had collected, the nova at no time ever displayed any motion other than that of the stars in the eight sphere, which the visitor seemed to always follow.\textsuperscript{180}

Still early observers seemed to have thought the idea reasonable, and leading: if the nova was moving away from the earth, what was it moving through? Possibly it was passing through the several spheres of the planets, as opposed to the single sphere of the fixed stars? Bad enough for an Aristotelian cosmologist to accept linear motion on the part of the nova; this was to throw a large monkey wrench into the cosmic gears of the universe. Worse still to suggest that objects might pass through one sphere to the next. This lead directly to the next difficulty: if the star was moving away from the earth, did this mean that the spheres which make up the heavens were possibly in some fashion porous or fluid like in their physical makeup; another problematic outcome for traditionalists who held the spheres to be solid.

Several writers explained the nova by suggesting that it had begun its life in the lower regions, and had migrated upwards into the celestial realm.\textsuperscript{181} This was worst of all: if the spheres were solid, as tradition dictated, how could anything, especially something some had accepted to be made of elemental, sub-lunar matter, rise into the ethereal region?

Finally, what did this say about any estimate of the sizes of the celestial spheres themselves? After all, if it was moving away from the earth, through a sphere or spheres,

\textsuperscript{179} Elias Camerarius: \textit{observatio et discriptio novi siderius, quod in principio octoberis Anno Christi 1572 Forma Stella Prima magnitudis apparuit}, 1573.
\textsuperscript{180} TBOO, vol. III: 211.
\textsuperscript{181} Ibid.: 138, 155, 294.
were they thicker than had been traditionally surmised? If it was in the eighth sphere, did this mean that this last visible sphere was bigger than originally thought; did it have three dimensions as some had seemed to deny? More problematic was the possibility that there was yet another sphere, beyond the last that had made up the edge of the universe, which the new star had exposed to man for the first time. Did the star’s dimming make the universe bigger than the Ptolemaic model suggest it should be, more along the theoretical size of Copernicus’s?

Tycho, in his later compendium of reports criticized his fellow observers for just such assertions. Astronomers that the Dane respected, like John Dee, Thomas Digges and Cornelius Gemma, however, had all indeed struggled with these possibilities, and had suggested in their public comments that the star had been moving away from the earth. Tycho, ever the logician as well as the precise observer, wondered why they could claim these conclusions to be the actual reality they struggled to discern. For all intents and purposes, the nova had displayed no real parallax at any time; this meant that, from the start, the star must have been immensely far away. If related to movement, therefore, something he denied, the star’s steady diminution implied a universe impossibly large; he no doubt having long accepted the more modest estimates of his intellectual forefathers.

Others chose to concentrate their intellectual energies on the idea that the star’s diminishing brightness was proof that it had been there all along. It was not unreasonable to suggest, given traditional—and it must be kept in mind, still much respected—theory,

182. Cornelius Gemma, De natura divinis characterismis, 1575.
183. TBOO, vol. III, 340. Much of the later third of the Progymnasmata is an extended criticism of other author’s theories, logic and conclusions.
that the star had been covered by some sort of cloud in the upper atmosphere which had moved away or had dissipated. Aristotle suspected that much of the boundary layer between the elementary region in which the earth sat, and the changeless celestial world, the place where fire found its natural home, was filled with turbulent gasses. He postulated that this was the region in which comets traveled. The cloud which was supposed to have obscured the star, however, would have had to be there thousands of years as there was no record of a star ever being there before. Could celestial matter itself have coalesced, or perhaps been added to an existing star? Bartholomew Reisacher, Vallesius and Hagecius’ friend Frangipani all took the star to have originally been the previously dim but cataloged Cassiopeia κ, somehow grown in size and/or added on to by some unknown means. As reference, Frangipani noted the story of the Pleiades, the constellation which had at one time been said to have seven stars, but now had only six.

In attempting to come to some conclusions about the possibility that the nova was a comet, a commonly held idea early on (note books with titles like: “Libro del Nueva cometa,” and Jean Goselin’s “La declaration d’un comete”), a brisk debate ensued among all ranks of commentators. Goselin reported that a number of observers in Paris had seen rays emanating from the object, one always pointing to the east. George Busch published his print of the nova with tails. Caspar Peucer and his colleague Heronimous Wolf initially wrote that it was a comet; they had detected a rather large numerical value of parallax. Tycho (who seems to have been unaware of Goselin’s report), sure from the

187. Dreyer, Tycho Brahe, foot note 1, 63.
start that the object was not of that species, responded to the arguments in favor, that
since the object had no tail, by definition it could not be a comet.\textsuperscript{188} He had been well
aware that both Peter Apian and Johannes Vogelin had in their work to discover the
Parallax of the comet of 1532 concluded that all comets’ tails pointed away from the
sun.\textsuperscript{189} Cornelius Gemma agreed, pointing out: “Even less can you say it was a comet or
an exhalation (ergo within the elemental region). In fact when did the cycle of comets
appear similar to this one, as all of them show a tail or a beard, or are in the shape of a
sword...Where is the irregular motion that always accompanies the exhalations ignited
by a law of nature? Comets always look gloomy and menacing, and they never
sparkle.”\textsuperscript{190}

A further conundrum grew out of its changing color. Could the nova actually have
originated in the atmosphere, below the lunar sphere, and then moved up into it, as its
initial brightness and subsequent dimming had suggested? This would imply that the star
could indeed be made of changeable matter, but this in turn lead directly to its own
troubling conclusions. As noted Caspar Peucer:

If gathered from material in the sublime and excellent celestial
region, we assert that perhaps the burning object has blazed up from
the radii of Jupiter or Venus. If it be elevated above the moon from a
huge exhalation from the earth, the doctrine concerning the
distinction of the terrestrial region from the elemental is
overturned.\textsuperscript{191}

If they even existed at all (as now seemed in doubt), did each celestial sphere
have its own color associated with its material? In a letter written by Cyprianus Leovitius

\begin{flushright}
\textsuperscript{188} Tycho Brahe, \textit{Nova stella}, also TBOO, vol. III: 206, 210, 215, 216.
\end{flushright}
that Tycho published in the *Progymnasmata*, the astronomer speculated that the star began its existence in the sphere of Saturn; hence its golden color, and had moved downward, into the sphere of Mars.¹⁹² Tycho replied that he had seen many stars that shone in varying colors, including those. As with virtually every commentator who suggested that the nova was nestled within a planetary sphere, the young Dane countered with the fact that no one (he respected) had seen the nova move along with that sphere’s assumed motion, only that of the eighth’s. Yet another theoretical monkey wrench was thus tossed into the mechanism: clearly no part of classical physical theory provided good answers to the questions posed by the star’s color shift. As interesting as the search for its location was, the problems suggested by its metamorphosis could be more challenging to be sure. By the end of 1573, the nova’s observers, who had scrambled to determine its location were forced to turn their attentions to the star’s changing physical characteristics. No good tool equivalent to parallax existed to quantify that information, and no rational deductions seemed watertight. All readily grasped the magnitude of the problems the change had thrust upon them, however, and in the end, no satisfying set of conclusions was ever agreed upon by all.

Tycho, while having no trouble finding, and publishing, the flaws in others’ theorizing, never found any sure means of discerning the true physical nature of the mysterious visitor himself. Nor did he seem particularly adamant to do so. As far as he was concerned, its very appearance seemed to negate the laws of constituted authority itself anyway. After all, if the new star was there in the heavens as was in his mind positively the case, what else might be there and why, and what could be said about all

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other previously respected knowledge and theory? Having to conclude something, the great astronomer ultimately side-stepped the central controversies that the new star had ignited: being as it was on the edge of the Milky Way, Brahe theorized that this cloudy band of light had provided the material for the nova, it having somehow coalesced into the singular object it had been briefly, before fading away. 193

Despite all the possibilities that the arrival of the star engendered, few saw the logic of its nature as leading to any sort of Copernican conclusion. That the nova negated central axioms of Aristotelian physics most seem to have been surprisingly quick to accept, regardless of the nature of their observations, or their religious and political leanings. Where that took natural philosophy, few were willing to guess in print. That some authors therefore, did tie the nova to the new Astronomy of the De revolutionibus is telling. For all the evidence we have that was put forth in published writings on the subject only one or two writers positively connected the nova with Copernicus’ moving earth, and the most vocal of these was Thomas Digges, in his Alia seu scala mathematica.

Digges’ creative thinking as well as his lifelong advocacy of the use of mathematics and mathematical instruments, help to explain the reasons for his being one of the more heliocentrically predisposed of the nova’s observers; a small group indeed. Modern students of the subject all give him credit for being among the most accurate of the nova’s observers (he used a ten foot long wooden cross staff in his observations). In publishing the description of his observations however, he seems to have had a broader agenda than that of simply describing and explaining the existence of new star. By now a

mature and well-known author of mathematical text books, he had benefited by his long apprenticeship with England’s greatest mathematical mind John Dee, as well as the technical expertise of Dee’s instrument maker and publisher Thomas Geminii.

Like many other books and pamphlets, Digges’ *Alia seu scala* was rapidly put to press. Undoubtedly he could have produced a far shorter work in which the nova was the sole topic. Discussion of the new star took up only the first dozen or so pages of the books one hundred however. Many works quickly composed in the spring and summer of 1573 had the same editorial framework: short on facts and largely (to us) tangential filler. For this matter, Digges chose to provide the reader with an entirely new method of determining parallax. Given the length and complexity of his arguments, Digges’ (and in his parallel work, John Dee also) clearly must have been developing his ideas, possibly, for years before the nova’s arrival. One senses that, as well as being a natural wonder, driving mystery and law shattering phenomena, the nova served just as well as advertising attraction.

Initially, Digges, along with most of his more practiced continental colleagues found no parallax. At that point in time, like everyone else who feared the star’s disappearance, Thomas sought to detect only daily parallactic shift. This makes sense in the rush to discover the star’s location as quickly as possible. As far as I am able to discern, only Digges deliberately sought to detect an annual parallax. Assuming the reality of a Ptolemaic geo-stationary earth, finding no parallax certainly created its own problems for the ancients and their contemporary supporters, but was entirely consistent with the idea that the new star was just a star, hovering in the heavens above an immobile earth. No parallactic deviation only implied that the star was far away, as far away,
minimally, as say Mars. Digges knew that the orbit of a mobile Copernican earth created a far greater base upon which to discover any such discrepancy. If, say, after four or five months, he was able to detect some difference in the star’s position from that initially measured, and given that none had been found before; this would be a great argument in favor of the earth’s movement. Unfortunately for Digges, neither Copernicus nor he had imagined just how big the universe really was.

His broader grasp of the theoretical implications of the new star did, however, lead him to make some other, equally important conclusions, and these in turn to equally interesting observations. As the months progressed, and the star grew dimmer, Digges’ colleague and mentor John Dee joined his continental colleagues and suggested that this implied that the new star had always been there: it had just been hidden behind some sort of celestial cloud, and was being covered up again. The English astronomer, not willing to let his opportunity to let the heliocentric model go so quickly, countered with the theory that the earth was in fact moving away from the star, hence its decline in brightness. He calculated that, sometime in the middle of June 1573, it would begin to get bright again as the earth swung around on its orbit. The star continued to dim. Again he was frustrated in his hopes; unable to make any conclusions that would weigh on the side of the heliocentrics.194

For all the good work and rigorous analysis that trained astronomers devoted to the new star, a far more common an approach to be discerned in coming to an

understanding of the nova’s import is reflected in the analysis of Francesco Maurolico, the Sicilian abbot to whom Christophe Clavius gave much respect. Writing, apparently to Clavius himself, almost immediately after its initial appearance, the Benedictine Abbot sought to relate the nova’s appearance to the many strands of traditional knowledge that made up the thread of European intellectual thought.

Maurolico had quickly made up his mind about the star’s location; like his colleagues across the continent, he had immediately set out to find its position. He seems to have quickly and firmly concluded that mysterious visitor was in clear violation of two thousand years of philosophical thought and official church doctrine: it was for him obviously to be located within the realm of the unchanging celestial heavens.

Whatever instruments he had, the Sicilian did not note in his essay; though his placing the star as did Tycho, at 62 degrees north of the celestial equator implies at the very least a certain adeptness in the handling of some sort of quadrant or astrolabe, as I have pointed out, not uncommon instruments in his day. Maurolico gave its longitude to be at the beginning of Aries, also consistent with Tycho’s estimate. As for any concern about the nova’s perceived motions, all one may say is that he was certainly very well aware of the issues that his colleagues around the continent would find interesting; he had displayed a professional lifelong interest in them himself.

Being unable to gather, and write about, much more information from the object itself, however, the Abbot surrounded this small collection of facts with a hodgepodge of literary illusion and prognostication. Appropriately enough for a cleric, Maurolico began

195. See Tycho, De Nova Stella, Hagecius, Munoz and virtually every author I have read follows this format.
his report with a quote from Genesis, from which he derived the fact that the stars and planets, sun and moon, as God’s perfect creations, must bear great influences upon the lives of men. He then went on to sight Ptolemaic and Alphonsine star charts at length, none of which noted the existence of the nova among the dozens of more familiar bright stars in the area the author took the time to list. Dante (the poet), Vespucci, the triumvirate of Caesar, Pompey and Crassus, the Emperor Charles and the Turk in Constantinople, Electra and the Nereid’s, Venus, mother of Aeneas, Mars, father of the founders of Rome all seem to bear some relation to the star’s mysterious purposes.  

For the Sicilian scholar, a respected public official and undoubtedly among the best educated of European intellectuals, the appearance of the new star of 1572 invoked the entire spectrum of western experience. Like virtually every observer on record, except Tycho, he wasn’t going to miss the opportunity to proclaim the second coming of Christ. Nor would he want to neglect parallels in the pagan literary heritage, the art of astrology, God’s messages to man and his final judgment. Whatever the new star might be, Maurolico was sure, the creator had placed in its fading light some message that man must discover. Cornelius Gemma, certainly found a similar inspiration; his illustration of the new star did away with vain Cassiopeia altogether, instead constructing out of the same stars an image of Christ on the cross: the nova being the top most star.

On the northern end of the continent, his Danish equivalent sought to evoke a similar sense of importance, noting in the first pages of the Nova stella how awe stuck he, the court and society in general around him were at its appearance. Rather than equate its

199. Dreyer, Tycho Brahe, 68, Tycho criticized his colleagues on this point; making parallels with the star of Bethlehem was faulty. That star had hung motionless over a town, he argued, and was only seen by three wise men, not all of Europe.
arrival with the classical cannon of Greek and Roman literature however, Tycho sought the import of its arrival in an astrological analysis of the novas position. If bulk is a measure of an author’s concern with a certain aspect of a question, then Brahe was demonstrably nervous. He devoted the last third of the *Nova stella* to judicial prognostication. Contrast this to his mathematical analysis of the nova, which took up just a handful of pages. Needless to say nothing good could come from the star said the Dane: unless the death of the Turkish sultan was considered to be an acceptable consequence of the new star’s arrival. Otherwise plague, misery suffering and unhappiness of rulers and ruled were certain to be somewhere ahead.

I cannot imagine that anyone who saw the star did not invest in some amount of curiosity, and feel a bit nervousness, about it. Such an event unparalleled in the history of the age could only have some significance, some message embedded within the light it shone down upon earth. To find out what that message might be, what the arrival of the star could mean, many who saw the nova almost certainly turned to the Bible, time honored ancient authority, or their astrologer. The natural philosophical heritage of the ancients, potentially more productive of some definite answer than the others, turned out to be equally barren: no astronomer found any good and definite explanation for the star’s dimming, its color shifts, its shimmering throughout the night. Some concluded that it had always been there, below the moon’s sphere, invisible only because blocked by an earthly cloud. Many continued to insist that, despite its lack of visible similarities, it must be some sort of comet. Tycho had little difficulty casting doubt on all these ideas. When it came down to his own speculations about the star’s physical nature, probably few of his contemporaries saw much value in them either.
Some who observed the nova took one further step beyond the intellectual boundaries which their heritage had delineated for them, however. Astronomers all over Europe turned from their theories, traditions, prognostications and philosophical debates; which after all seem to have had turned up nothing positive, to examine the results of their celestial measurements.
Fig. 17: An illustration from Regiomontanus’ De Trianguliis, Book IV, published in 1533, showing the basic figures used in spherical trigonometry applied by Tycho Brahe to measure the position of the nova. Below: Fig. 18: Tycho’s analysis of the new star’s position, in Progymnasmata.
Chapter Six
The Mathematicians Come to Some Conclusions

We have found the longitude and latitude of this New Star with the help of the infallible method of the doctrine of the triangles. Exactly how we went about doing this in finding sides and angles of the triangles are from the fourth book of Regiomontanus. This work was used because everything is closely tied together geometrically.

Tycho Brahe, 1573

If anything must be concluded from the narrative of the last chapter, it is that many of the most astronomically adept minds of the age sought to understand the nature and meaning of the nova in the light cast by the several traditions of Western culture; philosophical, logical, biblical, and literary, which were the foundations of the common intellectual disciplines of the age. They also spent as much if not more time and energy thinking about the “occult” meanings of the star as anything else. Were I to consider only these perspectives—as valuable as they might be for modern historians—I would conclude my work here; the examination of the response of the nova’s observers having proved interesting, but providing no great insight into the development of science in the late sixteenth century. Wonder aside, one might only be able to report that nothing was ever really confirmed about the new star by the natural philosophers who saw it and struggled to make sense of its assumed import. That is not the point of this work

200. Tycho Brahe, Nova stella, following folio 2b.
however: to demonstrate that those very responses are profoundly illustrative of the changing nature of the endeavor of natural investigation at a critical point in its history.

The greater literate world of late sixteenth century Europe greeted the star’s arrival by inundating its more narrow philosophically oriented community, the one we are interested in, with imaginative ideas, conjecture, opinion, groundless theory, needles panic, and just plain nonsense. Many of the most talented, best educated and professionally mature observers of the nova engaged in these debates as well, publishing curiously contradictory theories, printing wild speculations about the nature of the nova right alongside the results of their (to us) more sober observations and calculations. All of these are valuable in helping us take the measure of the age and of the moment; they are quite frankly as inseparable as are their more serious comments, whatever the intellectual basis of those were.

We also know that, mixed in with all the accounts of these individual experiences, and within the results of these disparate methods of “analysis,” there was scattered a sizable amount of matter concerning the mathematically based investigations of our subject observers. Here, more than any place else, as it turns out, is where astronomers like Brahe and Digges, Maestlin and Hagecius placed their best bets; that they could make some sense of the events they were witnessing, that they could find some absolute surety as the basis of their understanding of what they saw in the night sky, and, just as importantly, that they could find credible comment among each other.

I have deliberately left the heart of the matter of mathematical analysis aside until now. This is for three reasons: one, that there is a vast amount of material to distill, which
if given in great detail could easily fill its own volume. Secondly, much that seems reasonable and interesting to us here in the 21st century has to be teased out from among the sizable rest. This is an artificial divide, I am well aware, but still a valid one. After all, it is clear that Tycho and his immediate colleagues ultimately saw the efficacy of his mathematical techniques above all others, why shouldn’t we?

Thirdly, it is my thesis that here, in the immediate and unplanned response to the nova, and later through the reflective comments and pointed editing we can see most clearly the central beliefs of the age’s best and most creative and imaginative astronomers and cosmologists (not to mention the rest of literate Europe). We may see how they sought, in the aftermath of the star’s arrival, how best to gather what they felt to be reliable data, and by what intellectual tools they had at hand to dissect that data. I have suggested that in this part of the response to the new star, and in the various levels of respect it garnered from others, we may find the measure of the extent to which the modern premises of science had gained currency among the natural philosophers of the late sixteenth century.

The reader may find in this aspect of the nova’s recorded observations resounding proof that astronomical research, along the lines that modern astronomers would well understand and appreciate, was a very active ongoing project, taken up by a considerable part of the age’s community of astronomically inclined natural philosophers. In no uncertain terms it can be stated that they looked to the new field of trigonometry and to well-made instruments like cross-staffs, sextants and globes to answer their most

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201. Much of the 340 or so pages that Brahe alone compiled and Dreyer edited, or any of the dozen or so extant texts that were published at the time of the nova, and not included in their entirety in the Progymnasmata.
important questions, with demonstrably more faith in the possibility of finding useful results than logic, argument and received tradition. The relative extent to which they valued these other tools is a measure of just how far down the path towards our vision of the scientific enterprise late sixteenth century astronomy had gone.

I have discussed in brief the lives and works of some of the observers we should be concerned with, their educational backgrounds and the intellectual milieu they inhabited. I have also enumerated the theoretical devices and the conceptual tools they had on hand to dissect the various meanings of the star. It is now time to look into what it was that they measured, precisely how they did that, and what they discerned in the light of the new celestial object.

The phenomenon of parallax that had promised so much to astronomers in November, 1572 was then known to be practicably measurable in three different ways. In chapter three I noted that Claudius Ptolemy, medieval and Renaissance Europe’s greatest authority on the subject, used parallax to ascertain the distance of the moon from the earth. The Alexandrian seems to have been quite sure that no one had ever found any sort of parallax when observing stars, so, it seems, he never bothered to record any of his own efforts had he even made any. His method was to be used for finding out how far the moon was from the earth. The very idea however, serves more importantly for us as inspiration to those who wished to find out where anything in the celestial regions might be, and would have preferred to go look themselves rather than read an old book to find out. From the point that Ptolemy had left off, it was a short logical distance to using parallax to determine the “true” size of the universe.
Since Ptolemy’s publication in the second century C.E. observers of the heavens reading his text had made a hobby of trying to discern some parallactic shift in anything thought to have even been remotely possibly beyond the Moon and had like him signally failed to do so. Most recently for nova observers were the comets of 1532 and 1551. Efforts to find some shift in both were pointedly futile. Medieval and Renaissance astronomers had, however, been able to mimic the Alexandrian’s achievement and measure a lunar parallax of about two minutes of arc by using Ptolemy’s methods. This certainly was an indication that the idea was sound, and that their skills were up to the task.

In the same way as had the Aristotelian tradition of causal physics informed the nova’s investigators, two thousand years of Hellenistic astronomical tradition thus ennobled this first method I shall describe here, found in the fifth book of the *Almagest*. When 15th-century Natural Philosophers began to investigate that universe beyond the moon, they had a readymade means of measurement right at hand. In that book, Ptolemy began by describing the construction of a parallactic measurement device. Like all the other pre-telescopic mechanical contrivances mentioned here, it was in principle made up of a very few, simple parts, put together in geometric symmetry. It consisted of three straight lengths of wood or metal: one vertical, another, the sighting arm, hinged to the top of the vertical piece and made to rotate around that axis, and a third running along the base of the sighting arm to the base of the vertical shaft (see illustrations below).

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The sighting arm had a small eye hole at the lower end, through which an observer looked, upward, aligning the sighting arm with the moon’s position, through a larger, moon sized hole at the top of the arm. Judging from this aspect of its architecture alone, it was designed solely to observe earth’s satellite. The swing arm was aligned with the moon, and a length was measured on the lower connecting arm. This represented the chord of an arc, for which one could find an angle in the tables of the first book of the *Almagest*.

*Fig. 19: Depiction of Ptolemy’s Parallax measuring device*
The device was to be used twice a year: at both the spring and the fall equinox. This was because at that time the moon’s two positions would be at their maximum separation in longitude, and also, at a point of known longitude, and therefore display the maximum deviation from their predicted positions that would represent its error. The first measure, found at spring equinox, was thought to be the most accurate, and thus became the reference. The next sighting, some 180 days later was thought to be more possibly erroneous, because of parallactic shift. The difference in degrees measured between the predicted location of the fall measurement and observed reality constituted the numerical value of the Moon’s longitudinal parallax.

One great problem with this method was only partially addressed by choosing these specific dates: the estimated time upon which the Moon reached the equinox point. Ptolemy picked these dates because they were relatively easily predicted. Neither he, nor any one before the late seventeenth century had any sort of clock which was accurate enough for the needs of the astronomical research of their day. The Landgrave’s Wilhelmsuhr, for all its complexity and precision ultimately did nothing to advance research. Joost Burgi’s many later clocks seemed to have fared no better. Tycho, decades later, was said to still be using clepsidera, “waterclocks,” as had ancient Greeks two millennia before.203

Ptolemy worked out in detail the means by which one could convert the numerical value he derived from his biennial observations to a ratio, which, when compared to the radius of the earth produced a set of maximum and minimum values for the distance of

203. Dreyer, Tycho Brahe: 324.
the moon’s epicycles and deferent.\textsuperscript{204} This method relied entirely upon the logic and premises of Euclidean geometry and was not dissimilar to the “method of exhaustion,” devised to find the area of a circle. The Alexandrian could assume that the distance to the sphere of the stars was so distant, that the angles of his earthly triangles (those he drew to represent the radius of the earth, the viewer’s place on its surface, and the measured arc of his parallax) were all either right angles or otherwise vanishingly small. Using this method, he determined that the moon’s deferent was roughly forty earth diameters away.\textsuperscript{205}

As much of a triumph as this exercise in observational and mathematical skill was, Ptolemy seems to have left it at that. No records exist of any attempt by him to measure the distance of any other celestial object. Note: as I said in the last chapter, with this figure, and the theoretical constructs of his model, a contemporary cosmologist could deduce an estimate of the size of the universe: a central point in all of his investigations in the first place. So maybe Ptolemy felt he did not need to look further for some hint of planetary or stellar distance. The Sun’s displaying parallax, though mentioned as a possibility, seems not to have been a focus of attention for astronomers until Tycho’s work at Uraniborg, in the decades after the nova.\textsuperscript{206}

Much credit must be given to the Alexandrian for his efforts, given the tools at hand. Several overall problems existed however, in his procedure that need be mentioned. Like many practical applications of geometry, this strategy produced only an approximate measurement. And only of the Moon at that. The chord charts of book 1 of the \textit{Almagest}
only produce results down to a half a degree. This is really very accurate, except when
the entire final observational parallactic deviation might be two degrees. Having a plus or
minus \( \frac{1}{2} \) a degree range of accuracy introduces as much as a 25% error in one’s
calculations. As fine a measurement as one can make with any device will not negate this
problem if one must use these basic cord charts. The value of Euclidean geometry as a
practical tool does have its limits. If one wishes to understand purely abstract
relationships of lines and shapes, there has probably never been a better tool. Should one
wish to survey the size of farm fields for tax purposes, it is essential to grasp the basic
axioms and propositions we now think of as Euclidean. If one wishes to measure
miniscule arcs using Ptolemy’s fractions and roman numerals, it cannot be thought of as
terribly accurate.

Ptolemy would have to have built a rather large instrument, in any case, to
produce raw data of any value. J.G. Toomer’s translation, which I use here, quotes him as
requiring the arms of his device to be minimally four cubits long, about six feet “so as to
admit finer graduation.”\(^{207}\) He was certainly aware that greater accuracy depended upon
the size of his instrument. With hindsight, it can be seen that medieval astronomers, who
seem to have relied extensively for their observations on smaller handheld devices like
astrolabes, had no chance of matching Ptolemy’s results. Before the sixteenth century and
the development of larger, better designed and constructed equipment, the best
astronomers might do is to discover some parallactic error in the moon, and nothing else.
But for them, what urgent question about the stars presented itself anyway? They weren't
going to move, or change their color, or just appear anywhere out of nothing, were they?

\(^{207}\) Ibid., 244.
The extent to which these astronomers knew that their astrolabes and gnomons were at best vague indicators of position is hard to determine. The push among Western instrument makers to develop more accurate instrumentation in the century before the nova is certainly an important indication that Renaissance science understood quite well previous ages’ failings and how to remedy them. With the development of such tools at the sextant, the cross staff, and better armillary spheres, observers might well be presented with a choice of techniques. The subtleties and strong points of each instrument design might have made it hard to choose between any one over another. All ultimately relied upon comparing the position of the star in question to its surrounding stars; but there are more ways of doing that then may at first seem apparent.

The first alternative to Ptolemy’s now 1200 year old recipe was suggested by Johannes Regiomontanus in the 1470s. This, our second method, became available to a wide audience in the first posthumously published volumes of his De triangulis, in 1533. Brahe knew what Regiomontanus had achieved as indicated by the fact that he described it and gave credit to its creator in his Nova stella while only mentioning Ptolemy once, in passing, in a paragraph having nothing to do with locating the nova’s position. This was in part because Regiomontanus’ system allowed the observer to make precise observations of stars as well as the Moon, in units as small as one would like, and note them in Arabic numerals, which were far easier to manipulate.

The fifteenth century astronomer and author had at his disposal the mature science of trigonometry. Ptolemy, when developing the cord tables in book 1 of the Almagest was using a very simple, limited form of that discipline. By the 1470s all of the functions necessary to discover all of a triangle’s angles and sides were well understood, even as
used to measure those laid out on the surface of a sphere. This meant that, in practice, an observer could calculate the separation of objects just a few seconds of arc apart from each other, assuming his measuring device could distinguish that small a separation.

Using Regiomontanus’ methods, that observer needed to locate the positions of just two stars relatively close to the object in question (i.e.: our nova). As a third point, he or she used the celestial pole. In the last months of 1572, Tycho was able to quickly locate the positions of two stars located in Cassiopeia. He used the positional measurements of another famous astronomer familiar with Regiomontanus’ work: Copernicus.

With the pole star, these stars made up two curving triangles extending “downward” towards the ecliptic, one line of which could be the observer’s meridian. Tycho could then locate their positions accurately on that great circle. He created a third triangle, made up of the lines between the first, “meridian” reference, and then each of these to the nova.

That triangle’s side’s lengths could be determined by trigonometric analysis, converted to degrees and minutes, and those numbers extrapolated to the meridian to find the nova’s true position more accurately than ever before. In a pinch, he could use this method on any set of three stars, using two to map the third. This method freed the observer from awaiting the equinoxes; he could go out every night to search for some parallactic shift in the heavenly bodies. It also helped to perfect the universally understood notation of the star’s position; the “Right Ascension and Declination” grid that astronomers had used for millennia. Astronomers across the world could develop a
far more accurate idea of where a celestial object was. Though he initially borrowed from Copernicus, in his later *Progymnasmata* Tycho reproduced his own similar studies of every star in Cassiopeia showing their latitudes and longitudes, the product of his subsequent decades of study, technical development and experience.

A reminder: the post Regiomontine observer was now looking to find parallax of stars as well as their precise positions on the grids that made up celestial coordinate systems, and in our case an object only suspected of being a star, something that Ptolemy seems to have made no recorded effort to do. Numerous authors’ effusive praise for the
system described in *De triangulis* is both an indication of their respect for the new technique, and also, a measure of the difficulty of the task before them using the Alexandrian’s second century methods.

Again however, accuracy was limited by the observer’s ability to measure time. The first meridian line measurement was the “base” measurement, but one must then await a given specific amount of time before making the next positional calculation. Just how long that unit of time was, continued to constitute a real dilemma. Regiomontanus solved this to some extent by instructing the observer to take a second set of stellar positions: those of the latitude and longitude of a known fixed star at its rising (a time that was easily predictable, much of the *Almagest* given over to determining this), and again at, say fifteen degrees above the horizon, which would count out specific degrees of change of all the stars in the sky, including the one under investigation. At the point at which one saw the reference star at the fifteen degree mark from its original location, one measured the position of the suspect star: in this case the nova. Any difference other than fifteen degrees would constitute the object’s longitudinal parallax, discernible, depending upon the accuracy of one’s instruments, to a few seconds of arc.

To take full advantage of the potential accuracy of this method required something that Ptolemy understood the need for perfectly well: large instruments. As I have said, few in Europe were in a position to own these, however. Tycho, Digges and Wilhelm of Hesse and few others were among this list: Tycho his five foot sextant, Wilhelm his armillary sphere, and Digges reporting that he had on hand a ten foot cross staff. Tycho paid much attention in his *Nova stella* and in his *Progymnasmata* to the
results reported to him by Paul Hainzel, the official of Augsburg, for whom after all he
had built a nineteen foot quadrant; probably the largest instrument in Europe in 1572. 208

We know only a few broad facts about the equipment Wilhelm and Digges used,
much more about the instruments that were designed and implemented by Tycho. 209 This
is because, decades later, in both his Progymnasmata (recall, it was published
posthumously, in 1602) and his Astronomiae mechanicae, also a later work, he described
and illustrated the sextant he had built sometime before the nova’s appearance and with
which he used to observe the visitor. 210

Itself an imposing instrument, it had a length of roughly five feet on a side. Made
to be stationary, Tycho had to have it hoisted up to an appropriate window and firmly
mounted to the building structure itself. A plum-bob set the device at level. A brass screw
could be adjusted to tiny fractions of a full turn, moving the upper arm just fractions of
degrees of arc.

There was a trade off with its basic Euclidean geometry. The sextant only had an
effective arc of 30 degrees, but because of its size, its arc could be divided accurately into
minutes, perhaps the first device other than Hainzel’s known to be so divided. Its
designers, it appears, saw the need to compromise between, size, accuracy and versatility.

Interestingly, the whole instrument’s operational results could be measured
against a known design error. True final measurements were adduced through Tycho’s

209. A pair of paintings of Wilhelm and his wife that have survived display astronomical instruments as
props in their backgrounds; these are thought to be accurate illustrations of his equipment, as well as
including a portrait of Tycho Brahe in the back ground of one. See: Mosley, Bearing the Heavens, 42 - 43.
post observational calculations. This error arose from the fact that the observer’s eye was not truly at the center of the arc of the sextant, where the measurement was coordinated, and therefore would induce a geometric “non-symmetry,” one that would increase with the angle of measurement.

![Fig. 21: Tycho’s calipers and his illustration of its inherent error. The observer’s Eye should be at point “I” but instead is usually at point “A.”](image)

Tycho showed in his later calculations that he knew to adjust his results accordingly. In later years, Brahe simply redesigned the sighting device to eliminate this and other mechanical errors, removing the need for these additional post-observational calculations. This early design work almost certainly constitutes the first recorded instance of an instrument designer understanding the inherent errors built into his device and actively compensating for them mathematically. Given that most astronomers had nothing as accurate and elegantly thought out, I feel it is safe to say that most who knew of Tycho’s improvements (and he was the sort who did not shy away from broadcasting

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211. See illustration and explanation in TBOO, vol. II: 263.
Fig. 22: Tycho’s five foot sextant
his achievements) were willing to accept his authority on the subject of the nova’s position. Interestingly, the Danish astronomer’s instrument was unable to detect a 1/3 minute difference that would have allowed him to observe the tiny change in the nova’s position due to the then still largely theoretical precession of the nodes. Here was the boundary of a vanishingly small design limit of late sixteenth century astronomical engineering.

Though there were similarities, Regiomontanus’ method was not the same as the method published in both Thomas Digges’ *Alea seu scala mathematica*, and John Dee’s *Paralacticae nucleus*, entirely independently of Tycho, in England, at the very same time as did Brahe publish his *Nova stella*. Digges made it a point of mentioning Regiomontanus and his work on almost every page of his short work, mostly, it seems, to point out the chronological shortfalls in his technique. It has been argued that both Digges and Dee rushed their texts into publication, four months after the star’s first appearance, not so much to contribute to the continent-wide discussion then taking place, as to advertise their new method of determining parallax. Given that each text contains far more general and advanced mathematics than nova discussion, it seems fair to suggest that the two had already worked out the details of their new mathematical system beforehand, and might have seen the opportunity to advertise their innovation. While certainly useful in that it eliminated the need for an external measure of time, Digges’ and Dee’s methods required many more measurements than that of Regiomontanus, each of

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which was bound to consume time and lessen accuracy. This awkwardness seems to have prevented its wide spread dissemination.

The last of the three means of discerning the parallax of a celestial object known to sixteenth century astronomers was by any standard more primitive than the two I have described above. It got its trial, however, as did the others; and quite likely far more so. Its simplicity, however, was not necessarily a problem if all the observer wanted to do was discover one object’s suspected movement relative to other nearby objects—in this case almost always the nova’s stellar neighbors in the constellation Cassiopeia—over several weeks and months. Such an innovation, one that might seem to us at first to be intuitive, was the idea of just measuring the arc between one star and another.

Ptolemy had obviously spent years craning his neck towards the night sky and had published pages of stellar positions, marking the whereabouts of stars in a system of latitude and longitude quite similar to the one we use today.\(^{213}\) This is what more advanced astronomers in 1572 had wanted to accomplish with the nova: placing it precisely on that grid system and so allow for the accurate comparison of their results with those of other astronomers across the continent. Finding the straight line distance on the arc of the great circle that passed through each one as described above was a complex matter altogether, and for what many wanted to know, not necessarily important, especially when trying to pinpoint the location of an object in the heavens that had not been there the night before, and might very well be gone tomorrow.

Given just about any stable measuring device this method would more than adequately determine if the object in question had shifted towards or away from its

\(^{213}\) Ptolemy, *Almagest*, Books VII and VIII.
neighbors. This was the method used by Michael Maestlin, and required, in his case, a piece of string. Some observers seemed to have used the services of a ruler. The cross staff, a not necessarily much more accurate device, seems to have been the tool of preference for a number of others across the continent.

Here, the idea was to select any four stars that made up the corners of an “X” such that the object under observation sat at the exact center of that “X.” As seemingly primitive as it may seem, it had advantages. Given the vast number of stars to choose from (more than 1022) finding the appropriate references was fairly quick and easy. On the assumption that these, which after all were supposed to have not moved in millennia, were immobile themselves, simply halving your string gave an accurate if non-numerical result. With a bit of patience one could well assign numerical values to the measurements if one chose to, but these ultimately would be entirely relative to any particular standard the observer might come up with, and therefore not necessarily of much value to the greater nova watching community. Further, pretty much every serious astronomer of the age knew perfectly well of the defects of the Ptolemaic/Hipparchian star positions. Whatever it was that had gone amiss in the previous thousand years, those ancient values could hardly be thought of as an accurate description of any current reality. Observers of the moment were stuck with what they had on hand; a patiently and closely made measurement on any scale was almost certainly better than none.

Despite its decided lack of accuracy and the difficulty one faced in converting its derived data into a more universal form, its simplicity recommended itself: the door was open to anyone who wished to make observations: a far larger number than otherwise

214. Dreyer, *Tycho Brahe*, 59, Digges is reported to have also used this method.
would have been the case. One can imagine that Maestlin had used this technique to follow the course of planets in the past, they would have moved great distances across the sky in the course of the year, and he would have had to find many “X”s. This might explain the confidence he publicly displayed in his tools. 215

The cross staff user was not much more put out of his or her way when trying to come up with usable data. The observer placed the end of the cross staff to his or her eye, aimed the device towards the object in question, and slid the cross-beam along the shaft to align it visually with the objects assigned as the ends of the “X.” At a given point on the shaft, with the ends of the cross-beam lined up with the observer’s line of sight and the shaft aimed at the object of observation, one found a marking, which equated with an angular quantity. While this was technically more refined than a simple piece of string, it required about the same steadiness of arm, and therefore could not be counted upon even by the best observers to be accurate within a few minutes of arc. Indeed, it must be remembered that the cross staff was primarily designed for use at sea, on rocking boats, where any level of accuracy was unlikely anyway. As much as any other consideration, its prime virtue could be its cost: a reasonably good one could be assembled in an afternoon out of scraps of wood or metal. Needless to say, one imagines the high-end models (like the one we imagine Digges sported) to be considerably more. Much of the epistolary response to the new star that Tycho received from around the continent (that he thought respectable enough to consider, in any case) seems to have come from observers who used such tools.

When they sought to quantify the position of the new star—at first done in considerable haste—serious astronomers initially produced figures that ran the gamut from pretty accurate to as much as three or four degrees in error in their parallax measurements. Some found greater discrepancies. More than one, as can be imagined, who made initially wide measurements corrected them over the coming months. It is obvious that, at least in one case, initial reported observations were superseded by later, more accurate ones; implying that Tycho’s (whose collection I rely heavily upon) correspondents either then built better tools and/or got better at using them.

An important point about this source needs to be made here; and I have touched upon it briefly in Chapter Four. In the literary give and take of 1573 and 1574, one may see a sort of conceptual consensus develop among those whose reports were written as the nova was shining, but recorded decades later by Tycho in the *Progymnasmata*. There is a reason for this apparent synergy. I suggest that, in his long career before that book’s publication, as the Dane built and used the equipment he installed at his observatory Uraniborg, and as he further matured in his field, he seems to have developed a thoroughgoing and finely set intellectual filter with which to pass the works of others, and to arrive at a judgment about their value.

In 1573, as letters and pamphlets passed from one hand to another, the observationally adept naturally took greater interest in the results of their skilled peers than of those who might be making “good tries.” Still, pretty much everyone who seemed to be a serious observer got their chance to make comment before the citizens of the republic of astronomical letters. We know that lots of material got published, and lots of it was read by dedicated astronomers. Much of this is now lost to time. By the 1590’s, as
Tycho settled down and began to sift through the artifacts of those years, his sense of value, and perhaps of cynicism, had become attuned to the priorities to which he had dedicated himself in the previous decades, and that had guided him during the bulk of his best professional years.

In the earlier of his two books, in the course of discussing the nova, Tycho made reference to every concept discussed in the previous chapter. He did so with little discrimination between one of those concepts represented and another. Aristotelian analysis of the nova’s appearance went hand in hand with mathematical data, and astrological commentary. Many of his co-authors of the years 1572-74 did the same thing. In the rush to make sense of the star, it seems that just about any idea was worth considering seriously.

By the 1590’s Tycho’s philosophical perspective had matured, his intellectual skills sharpened. Throughout the pages of the *Progymnasmata*, its author and editor chose to assert the ascendancy of the mathematical and observational over any other of the possible ways of understanding the nova’s import. After describing once again his first sighting as he had in the *Nova stella* (and that farmers, carters and sailors had done a better job of discovering the nova than had the erudite), Tycho began that work with a thorough exposition of his, and Paul Hainzel’s equipment, providing illustrations of them, instructions for their use, and the results of their observations.

At the very start of that chapter, he made clear his scientific priorities: his was not to ignore the Peripatetic scholars with their Aristotelian logical constructs. They after all had claimed to advocate the veracity of the results of observer’s external senses. These however necessary as they were, were insufficient. With different machines ("Artifices
varia Instrumenta et Machinas”), and with geometrical analysis, he repeatedly declared, the star should be accurately described (denotarent; “noted”). It would be found to be in the aetherial realm, too far away for human vision to discern, and too far away to physically describe (“magintudem veram exacte demensurus”). Only by the use of exact measurement would true knowledge be found. Humanity, its logical constructs, and its senses alone were inadequate to the task of discovering truth. The Dane went on through the first third of the book to describe in detail his entire set of mathematical tools, and the reasoning behind their uses.

In virtually every analysis of his colleague’s work that he then enumerated in the Progymnasmata, Tycho prefaced his comments with an exposition of these values. Correct results may be gained only though “diligent observations,” “geometric demonstrations” and the use of “precise instruments,” diligently manufactured, he insisted. Again and again, throughout the compendium, Tycho referred back to this set of criteria, measuring his collected comments against this standard, and contrasting this with what, by the time of his death, had become a more than suspect epistemology. Aristotelian logic and the age’s received knowledge were plausible, yet they could only amount to conjecture and opinion. Traditional natural philosophy was “spinosae” (full of thorns), less meaningful “quam certae experientiae aute e competentibus Observationibus deductae demonstratum geometricae.” (than either from unerring experience from competent observation{or}deduced from geometric demonstration).

217. Ibid., vol. III: 382 and 227, similar words and phrases are widely scattered though out the entire Progymnasmata.
As I have pointed out in earlier chapters, as they wrote their first comments on the nova, men like Brahe and Hagecius did not scrimp when it came to commenting upon the works of observers whom they thought were wrong in their conclusions. Rarely did Tycho bother to include these authors’ entire work in his later book. However, he paraphrased their statements, occasionally printing short exerts, then almost always devoted pages to either polite disagreements, or the leisurely and rational destruction of their credibility.\textsuperscript{219}

Interesting exceptions to this editing rule are instructive. Found whole in the \textit{Progymnasmata} are correspondences between one of Tycho’s teachers, Caspar Peucer to another well known astronomer, Prince Wilhelm; an entire lecture given by Paul Hainzel, and the complete report of Michael Maestlin. Two can easily be identified as his youthful associates, all contain detailed mathematical analysis that Tycho had agreed with.

With his fellow mathematicians one senses a different set of priorities than that of the run of the mill nova commentator. In almost all cases, despite a sometimes considerable difference in the numerical positional values his correspondents reported, their results and ideas are added in detail, compared to others, and always admired by the author. No mathematician can be called “\textit{ineptus},” or “\textit{ignoratus},” as had Frangipanus and Hanibal Raimundus. Brahe’s geometers are instead “\textit{doctisimmus},” “\textit{clarisimum}” and “\textit{eximius}” (exceptional).\textsuperscript{220}

Chief among the work of his peers that he was to publish in 1602 was the Landgrave of Hesse, whom in fact at the time of the nova Tycho barely knew. Wilhelm’s

\textsuperscript{219} \textit{Ibid.}, vol. III: 254-259.
\textsuperscript{220} \textit{Ibid.}, vol. III: 167, said of Thomas Digges.
reputation was then, in 1572, widespread however, both as an observer, and as a maker of instruments. At first seeing the star, on December 3rd, the Prince and his staff immediately began to take measurements of its azimuth and altitude (locally referenced, and not particularly valuable elsewhere). Throughout December, referencing the sun’s position, he continued his readings, sometimes four times a night. On the 11th, he took three measurements within nine minutes, searching, it seems, for the minutest error in position relative to its surrounding stars. On the 29th, he took readings at four in the afternoon, before the sun fully set. Work continued in this fashion until March. Transposing these numbers onto a grid gave Wilhelm the position of 28 degrees, thirteen minutes below the pole star (remember Tycho’s 62 degrees north) about which it rotated just as had every other star the Landgrave had been watching, and with them the only motion he detected. With these numbers, Tycho had no problem producing his own more universal right ascension and declination positions; information that would be more readily useful to anyone wishing to put Wilhelm’s data to use in their own considerations. Here, he found interesting discrepancies. Wilhelm’s declinations were well within any margin of error in comparison to his, the Landgrave’s right ascension remained steadily off however, by two whole degrees throughout the months of December through Match 14th, about when he sent off his observations to Tycho. The Dane adduced that Wilhelm’s clock was most likely off by a few seconds.

Wilhelm and his staff—Burghii and Rothmann, no doubt—ultimately found that the star showed a parallax of about 3 minutes of arc, but willingly admitted that their

221. Dreyer, Tycho Brahe: 57.
223. Dreyer, Tycho Brahe: 57.
equipment was not capable of greater accuracy. Within the bounds of certainty, as far as that could be found, the numbers had proven that the star must be beyond the Moon.

As did others, Thaddeus Hagecius, at the imperial court in Prague, quickly published his succinct comments and measurements. These latter included a geometric figure of the rhomboid which sides consisted of the lines drawn between the nova and three stars in Cassiopeia. Each side of the four sided figure, and the lines crossing the corners of the box had a numerical value: the sides between 5 degrees, 15 minutes, and 4 degrees, 36 minutes. This method of placing the nova, strictly within the vicinity of its neighbors is a demonstration of the last of our three methods. That Hagecius provided numerical values for the lengths of his rhomboid sides is an indication that he used some device like a cross staff, capable of some level of accuracy, but by and large independent of any greater latitudinally-based means.²²⁴

Hagecius must certainly have been aware of the potential shortcomings of this method as well as its virtues. Perhaps to give the reader another perspective on the nova’s location the emperor’s doctor repeated Hieronymus Munoz’s figures, with which (for added gravitas) the court mathematician in Vienna, Paul Fabricius, he reported to have concurred. Munoz, in Valencia, seems to have used the same system, and had found a only few minutes discrepancy from the star to star measurements of Thaddeus.²²⁵

Later in his *Progymnasmata*, Tycho made much of the rhombus. Brahe was impressed enough by Thaddeus’ observations and analysis to include a summation of each of the chapters of the *Dialexis*. A brief history of the nova began the excerpt, then a

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²²⁵ Ibid.: 15.
description of the star’s position. Interestingly, in this later rendition, the numerical values are slightly different: roughly two degrees are added to each side. Next to those of Hagecius Tycho included his own measurements on his own similar figure, which differ by two to four minutes each. Included in all of these illustrations is Brahe’s “undecemam,” (the Ptolemaic “Erection Sedis,” the back of the chair), for which Frangipanus was so roundly chastised. Despite differences of a few minutes in their separate observations, both astronomers found that the nova was not in the same place as star number eleven.226

![Diagram of star positions]

Fig. 23: Tycho copied and added to Hagecius’ illustration for comparison, in the Progymnasmata

Also, interestingly, in his review of Hagecius’ work, Tycho found the space to include the observations and opinions of Paul Hainzel. Though no academic, he was

nevertheless the owner of Tycho’s nineteen-footer after all. Hainzel would continue to pop up throughout the entire work from time to time: a complete letter, written to Hieronymus Wolf on January 19th, 1573, his own published observations in comparison to Brahe’s and others. 227 This frequency I imagine is a good measure of the trust Brahe placed in Hainzel’s skill, and in the quality of the instrument he had built for him.

First using an old wooden quadrant, Casper Peucer and his colleague Wolfgang Schuler measured the parallax to be as much as nineteen minutes; a measurement that would clearly put the star below the moon. In the following weeks (Schuler is credited with seeing the star on the same date as Maurolico, November 6th, and thus tying him for first place), after Schuler had a more accurate and steady “triquetrum” built, and perhaps after getting some practice, they came up with a figure of around one minute; completely within the realm of any Tychonically acceptable error. 228 Despite their findings, Shuler never gave up the idea that the nova was a comet.

Plenty of others in the northern parts of Germany did worse. Tycho wrote the *Nova stella* as hastily as he did in part to combat the then current idea that the nova was below the moon; a direct response to the numbers of letters he received that included values as high as three and four degrees of parallax, some number that would have been easily detectable by just about any novice astronomer. Such measurements had the result of putting the star only about six or seven diameters from the earth; the area covered more usefully in the *Meteorologica* than in *De caelo*.

Many, despite having doubts about the star’s location, nevertheless found it to have displayed no parallax at all. Paul Fabricius, a doctor of medicine in Vienna who himself had transmitted precise latitude and longitudes of the star, concluded only that it could not be new planet, nor could it be as close as the sphere of Saturn.\footnote{229. TBOO, vol. III: 43.}

Tycho showed himself to be already very well aware of the best and most advanced mathematical practices in the spring of 1573. In the \textit{Nova stella}, as in the \textit{Progymnasmata}, the reader would find not just the astronomer’s results, but a detailed description of how he derived them. There he illustrated the new trigonometric methods he repeatedly credited to Regiomontanus, mostly, those found in the fourth book of \textit{De triangulis}.\footnote{230. Johannes Regiomontanus, \textit{De triangulis omnimodii}, Barnabas Hughes, trans. and ed. (Madison: University of Wisconsin Press, 1967), book IV.} Brahe also published illustrations of curving, three dimensional triangular towers, marked with points he identified as the pole star, the nova and the various stars of Cassiopeia. Knowing the latitude and longitude of any of the stars allowed the reader to derive the location of the rest (one knew were the pole star was, this didn’t count). The method was universal, and had as its only dependant variable, the accuracy of the known star’s position. These, in 1573, Tycho could only get from—you guessed it—the not particularly accurate accounts found in the \textit{Almagest} of Ptolemy, and the some what better off \textit{De revolutionibus} of Copernicus: “I have no certain observations, I do not wish to return to Ptolemaeus and Copernicus,” he wrote.\footnote{231. Brahe, \textit{Stella Nova}: folio B 3.} His life’s work was then calling.

As I have noted, putting the star beyond the moon, as many ultimately did, led directly to the next question, “where beyond the moon,” and thus into the realm of
unsubstantiated theorizing that made up parts of the last chapter of this study. It would say much if observers could pinpoint which sphere the nova resided in with certainty however; and as we have also seen in the previous chapter many made the effort, not particularly successfully. It must be remembered that, according to theory, the planets themselves were stars, no different in makeup then all other celestial objects, despite their differing motions and colors. The mysterious object might very well be far closer to the earth still than the eight sphere and nevertheless be categorized as a star. Very early on several astronomers, looking at their observational results, had voiced the idea that the nova resided in the sphere of Venus, others had placed it in that of Saturn.232

That it might be moving, up or downward, a commonly debated possibility in 1573 and 74, was to be discussed at length in the Progymnasmata, after Tycho had had decades to turn these collected arguments over in his mind. If he had, in the winter of 1572 used the rational arguments of the ancients to quickly conclude that the star was immobile and in the 8th sphere, by the later years of his life, he had digested and come to conclusions about many of the arguments that seem to point to other conclusions. The few sentences in the Nova stella that dealt with these ideas had by his death turned in to an entire chapter of the Progymnasmata. Again the astronomer sought to find a sure, numerical solution to this question.

The universe beyond the earth’s boundaries could be quantified, he was convinced, and not just by predicting the motions of the planets and stars. These could, in fact be measured in size, said Tycho. And if the nova’s true size could be measured, its distance could be well guessed at. He was by no means the first to suggest the idea:

again he could turn to Ptolemy (and to Copernicus) and the entire corpus of stellar observation to back up his contention. Using the traditional means of determining the size of the universe—finding the distance to the moon and working outward through the spheres—one could extrapolate the size of a first magnitude star, and then by reducing the remainder systematically by relative brightness, come up with a scale by which various magnitudes of stars determined their size.\textsuperscript{233} Each succeeding magnitude decreased the size of the star by a given ratio: this is what Tycho did at length in the seventh chapter of the \textit{Progymnasmata}, something entirely absent in the \textit{Nova stella}.

Coming up with the planet’s distances was fairly easy: as well as deducing his own distances he could rely on earlier attempts; most notably for Tycho the Muslim astronomers Albategnius and Alfraganus.\textsuperscript{234} Venus was thought to be 618 terrestrial semi-diameters away from the Earth, Saturn 4584, and so on, to the fixed stars of the edge of the universe, 19,000 semi-diameters distant. With this idea in mind, he next compared magnitudes, which represented apparent stellar size, and therefore distances, at some discernable numerical ration relative to one another.\textsuperscript{235} It is important to note that, to Tycho as with his colleagues, a smaller star was necessarily further away from the earth than a larger one. Recall that, over the several months of its existence, the nova declined in brightness; many had suggested in 1572 that this was because it was moving away from the earth in a straight line. Digges said this was because the earth was moving, not the star. But, Brahe pointed out, no parallax had ever been observed, both at its first appearance, and during the last weeks and months of its existence. If the nova was getting smaller because it was moving away from the earth, it must have moved an incredible

\textsuperscript{233} TBOO, vol. II: 429.
\textsuperscript{234} Ibid., vol. II: 417.
\textsuperscript{235} Ibid., vol. II: 431.
distance in order to shift the six levels of magnitude it had been observed to have dimmed (and he never accepted the Copernican heliocentric model which would have multiplied that numerical quantity).

By his calculations, using his model of distance and size, Tycho concluded that, in order for the nova to have done so, the universe would have to be about 300,000 earth semi-diameters in size; something entirely impossible to imagine. The Danish astronomer threw out the idea of the nova’s motion altogether.

Despite the years and effort of collecting and re-digesting nova reports that Tycho invested between the November night he first saw the star and his final collocation of the Progymnasmata, in the late 1590’s, he found few new questions had come to his attention concerning the star from among the citizens of the republic of astronomical letters. Few mathematically solvable ones could be asked, given the technologies of the age. But the one question that mathematics had best answered, and astronomers had the most confidence in, where the star was, was freighted with much of its own rational baggage, and, as such, provided answers that were the most suggestive and the most useful for the discovery of truth.

The value of that set of answers was based upon the surety of the method of their discovery, and, unlike all the other ideas and theories I have mentioned in previous chapters, mathematical measurement, in whatever form it came, was now, after the nova, clearly the most trusted method that late sixteenth century astronomers and cosmographers had at their disposal; even when it came to discovering new facts about the previously unknowable celestial region. Out of the vast realm of intellectual
endeavor, from all of the myriad ways that any one might choose to understand the nova, the age’s best minds found this to be their best chance at coming to any real and reliable conclusion.

It was a weighty conclusion. That the nova could be proven to be from beyond the moon meant that yet another pillar of the Aristotelian universe had collapsed. And one that was closely intertwined with the central tenets of Christian belief at that. It was a broadside into the central idea that God had made the universe of different things in different places, and that these places were governed by different laws. Because of the stark and dangerous conclusions this forced upon its observers, every serious western astronomer had very strong incentives not to find the star where they claimed they did.

The conclusion that the nova existed beyond the moon was reached using tools that had really had their birth in very practical pursuits, just as usefully used in measuring our world as the celestial. Perhaps the best measure (pardon the pun) of a fact or a theory was how it stood up in numerical analysis. Cosmologists and observers of the nova had used mathematical theory and measurement—and nothing else—to discover a new fact. Lots of new facts had been discovered in the preceding century, few if any of these could not be traveled to, touched, drawn in detail, dissected, carted back home or otherwise observed first hand in detail. That the nova even existed could initially, among some reputable authorities be disputed. After the fact of its existence, its most important offering, its place in the universe, could only be determined at a great distance. Mathematics, its observers came to realize in the months of its life, offered the only hope of determining this.
In contradistinction, not little else that was said turned out to be of much value. The only other thing one could do with the new star: observing its changing color and fading brightness, seems only to have created more uncertainty and more mystery at the time of the nova’s appearance. Not that this would be bad, still, the collective endeavor of science would have to wait centuries before it could make more of the nova than did Tyco and his contemporaries using cross staffs and sextants. Late sixteenth century’s other tools: received authority, logical deduction, proved by and large useless. For those who dedicated their lives to understanding the most subtle, complex, rational and powerful means of understanding nature they had been given by their intellectual forefathers, the signal failure of all but mathematics to provide any sort of meaningful answers must have been both disheartening and troublesome.

For those, on the other hand, who had been observing the growing creativity and practical usefulness of the new math with a sense of possibility, the nova’s arrival, its study and the conclusions educated people made about it must have been exciting and promising. As had never quite happened before (much like the nova’s appearance itself in the West), the vault of nature’s secrets had been opened and man had found a great treasure: his own ability, now largely engrossed and ever more powerful.
Fig. 24: Tycho was very respectful of his fellow astronomers, enough to include the measurements that they had sent him in his Progymnasmata, and include his own for comparison.

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ALTITUDINES STELLARUM ALIQUOT ILLUSTRUM CIRCA ZODIACUM IN MERIDIANO, PROPE AUGUSTAM VINDELICORUM OBSERVATÆ, EX QUIBUS INUENTÆ DECLINATIONES, CUM NOSTRIS AD INITIUM ANNI 1573 REDUCTIS CONFERUNTUR.

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Chapter Seven
To Make More Accurate Maps

If someone says it’s a star, he should not only demonstrate this through physics, but also through mathematical demonstrations and observations.

Cornellius Gemma, 1574

I do not know whether it is worthwhile to rehearse what all the historians of our age have recorded; that in November 1572 a new star was seen in Cassiopeia… it was in the celestial region, not elemental…they were of the opinion that it gradually disappeared by ascending, but they should have instead proceeded the other way around, starting with observed and known parallaxes and then considered the planetary theories.

William Camden, 1575

In some ways more familiar to its own age than ours, the nova’s appearance did fit in with the times perfectly well. For those who looked to the heavens hoping to see some connection with their lives on earth (as most probably did), the new star’s import might have been very clear. While it seems to have been mentioned in conjunction only rarely with the incident, just a few months before its first recorded appearance, France exploded into that national bloodletting known as the Saint Bartholomew’s Day Massacre. In the course of a week, somewhere between 20,000 and 30,000 French men and women, mostly Protestants, were murdered, often in public and under vicious circumstances.

Though there had been no fewer than three civil-religious wars that had violently divided the country in the previous decade, confessional boundaries had, in the spring and early summer of 1572, yet to harden to the point of complete fraternal intolerance. While the nova’s appearance metamorphosized from its original bright white glow to the
deep ruddy red it would remain until it finally faded into the black of the night sky, the dark consequences of the massacre settled on European intellectual and political life. As the fall and winter of 1572 progressed, citizens in all walks of French civil life grew to understand that Protestant leaders (the survivors, at least) the initial target of the assassinations, would never be able to put their trust in the Catholic king’s government again. The nova’s transformation from bright beacon to bloody cenotaph, surely must have seemed to mirror, or presage, events on earth.

The new star appeared just over a year after the battle of Lepanto, Philip II’s great naval victory that secured the western Mediterranean for Christianity, and sent untold thousands of Muslims (and their slaves) to their death in the channel between the Peloponnesus and the Greek mainland. Its stay coincided with the final suppression of the bloody four-year Moorish Alpujamas revolt in Spain, and the assault of the Dutch privateers known as the “Sea Beggars” on the Flemish port town of Brill.

Only a few months before its first sighting, in the spring of 1572, the last defender of the ancient Peruvian civilizations that existed before the arrival of the Spaniards, Tupac Amaru, had been captured, and then executed. His death ended the hopes of indigenous Americans for a return of their ancient society and traditions. Pope Pius V died in May. In his place was seated Gregory XIII, the reformer of the calendar and a man very interested in the popular sciences of the day: astronomy, cartography and geography, that then made up the field of cosmology. As the new star lit the night sky, Giordano Bruno took his own vows and entered the priesthood. Kirsten Jorgensdatter, morganatic wife of
Tycho Brahe conceived his first child in January 1573 and bore a daughter on October 10\textsuperscript{th} that year.\textsuperscript{236}

Chinese astrologer/astronomers observed the guest star, noted in their records its brilliant appearance and judged it to be an avatar of some vaguely sinister, possibly even destructive event.\textsuperscript{237} Western professional astronomers, when they wrote about the star, all added some paragraph or chapter that described the astrological influences that the nova was certain to inflect upon men’s lives. Universally, they were thought to be dark: the visitor was certain to bring trouble, violence and destruction, or alternately, the end of the world and the second coming of Christ.

Any detailed record of the impression the new star made on the multitudes of less literate or educated people whose lives were also affected by these events seems to have largely been lost to us. We know that much ink was spilled on the subject only because our most (astronomically) interesting sources commented in their own works how appalling this vast sea of chatter was. What messages the less literate masses read in the nova might have told us much about the hopes and fears of the millions of souls who lived in such turbulent times.

For those who made cosmology (and astrology) and the mathematical end of natural philosophy in general their business, the nova’s arrival was an unparalleled event, impossible to ignore, demanding investigation and comment. Even if the new star’s very existence seemed to defy the foundational theories on which at least some of their best

\textsuperscript{237} Robert R. Newton, Medieval Chronicles of the Rotation of the Earth (Baltimore: Johns Hopkins University Press, 1972).
tools were based, it could only be perceived by the light of the day’s beliefs, and understood using the intellectual and physical tools at hand. By the beginning of the 1570’s, however, most scholars and investigators current in recent events knew that these theories and tools themselves were undergoing a rapid evolution. The West’s leading astronomers had for a long time accepted that something was fundamentally wrong with their essential assumptions about the physical makeup of the heavens; just how much they did indeed feel so can be gauged by the loud, excited responses we have examined here.

The modern reader of the nova’s comments and reports interested in that intellectual evolution will find that the star’s arrival illustrated a growing divergence of two streams of the Western scientific tradition that had been intertwined for millennia, and had each in their own independent way supported the natural philosophical study of the heavens. One stream: that of the discipline of mathematics, had only recently been taken out of the realm of the principally theoretical and commercial, and handed over to the very earthy and practical endeavors of navigators, mechanics and land surveyors. More than had ever been previously done, our cosmos had come under the eyes of those who wished to picture it exactly as it was, measure every one of its corners and held confidently that they now had the right tools to do so. The nova’s appearance triggered a continent-wide effort to use those mostly terrestrial tools to find out the true nature of the celestial visitor. The response to the nova then, is a picture of the extent to which natural philosophers and investigators had become willing to accept the new tools of mathematics as a legitimate, even, the legitimate indicator of the validity of any bit of knowledge.
The new mathematics had told them something about the nova that deduction and authority couldn’t. Its answers told the investigator where next he or she had to go in their investigations, what work needed to be done, what new devices might be useful, and how to improve the ones that were on hand. It opened the conceptual door through which, if one were to pass, one could with little difficulty, transpose the laws of the sub-lunar realm into the celestial. Terrestrial mathematical systems like Euclid’s geometry and trigonometry did not stop at the edge of the lunar sphere, as had the physics of the ancients, only to become some other form of numerical construct. That the nova’s observers dissolved that conceptual great wall without hesitation is an indication of just how far and how widespread that the process of that dissolution had already proceeded. For the natural philosophers that saw the star, the most powerful and most useful devices on hand were the new mathematical instruments of the age: made by craftsmen and university trained instrumentalists alike, and designed for the very utilitarian purpose of gathering data.

The other stream, whose waters were made up of the classical heritage that crowned man’s rational powers as the great tool of his active intellectual existence, had only recently become muddied by the turbulence of the age’s new discoveries and inventions. The complex systems of logical deduction which had been laboriously constructed over the past four hundred years seems almost entirely incapable of providing any answers to the array of questions the nova’s arrival provoked. Almost all who witnessed the upheavals of the sixteenth century must have begun to distrust the way they themselves had come to understand the world. But they still saw that the intellectual traditions they had inherited were powerful and useful.
They were. Science even then was for all involved a collective social enterprise, as it had been for the ancients, and as it is today. Few then thought that the creation of new knowledge was the work of a lone individual, acting in isolation, sequestered from his surrounding intellectual community. Philosophers argued and debated with each other, they worked hard to understand groups of ideas and develop consensus about the phenomena of the world about them. Their tools of deduction and logic, debate and discussion, were the tools of collective action. Before such events as the arrival of the nova could be understood, natural philosophers must arrive at consensus about what they had seen. The means to do so were well in place long before the age of the nova: in the continent wide response to the new star can easily be seen the common language of scholarship, of shared assumptions and premises, disagreements, criticisms and occasionally insults.

In the end however, the intellectual tools of the ancients proved less than adequate to the task at hand. For all the postulating and posturing, serious observers found no suitable, no unerringly verifiable answers to many of their most pressing questions. Only more questions. As important as it is for an inquiry to bear fruit in the form of further inquiry, it can hardly be satisfying to have one’s efforts come to no fruition at all.

As it turns out, as the nova’s observers set out to learn about and understand what they were seeing; they used all of these means together as they had never used them before. Both streams of Western science: the mechanical-mathematical, and the deductive and purely logical came together in the researches and conclusions of the many who seriously thought about the nova. The necessary accommodation this demanded, between
tradition and observed reality, was to play an essential role in the development of modern physical theory and modern science itself.

Contemporary natural philosophy was very accommodating to later generations. Examining the record of the nova’s arrival, its life and eventual disappearance, more than other events of the age, has had the effect for me of uncovering and spotlighting the network of parties and individuals who took serious interest in the scientific endeavor of the day. The energy, openess and curiosity displayed by all whose observations were recorded indicate a well developed, self aware community made up of those with shared interests: a community that very much knew the value of leaving clear and valuable records for the future to ponder and use.

With impressive efficiency scores of notes and reports of the nova traveled across Europe. High-ranking Catholic scholars contacted Protestant astronomers, who paid close attention to what they said. Doctors of medicine in Austria contacted professors in Louvain. Spanish academics wrote reports for the emperor. In my research I have found no instance of confessional bias towards any member of the literary republic of nova watchers by anybody else, even as much of the rest of European society drifted into the depths of religious war.

Observers shared data, theories and guesses with apparently no fear of religious accusations or prejudice. The way in which all whose who wrote the records we have immediately understood the nature of the challenges they faced and how to surmount them is evidence of the level of common understanding natural philosophers of the age held. The nova could after all have simply been ignored, as it would appear its predecessors had been. Instead its arrival quickly triggered a continent-wide research
effort on the part of astronomers and scholars who saw in the nova a series of contradictions and mysteries. As “immediately” as that could have been in the sixteenth century, the active members of that community reported to their colleagues around Europe. Those mentioned in this study who worked to discover its nature and solve the mysteries the nova presented knew that they were a part of the greater intellectual effort, the participants of which needed and wanted their contribution and that they felt they needed to contribute to.

That community was large. I have noted that we have, literally, dozens of soberly written reports about the star that were quickly published and passed around the continent. It is fair to suggest that many more educated opinions have been lost to us. The community was intellectually flexible. Coming up with what in hindsight seems like a wild idea didn’t necessarily label anyone as an incompetent or an idiot (except for poor Frangipanus). The broad array of explanations and theories floating about in 1573 and later is really indicative of the intellectual and scientific creativity of the age.

As to the very first of the mysteries the nova presented its viewers: where was the star in the first place, the nova’s appearance set off an unintentional race to see who could make the most accurate measurements of its position. In that race, more than ever before, astronomical instruments were refined and perfected, and the traditional standards of stellar accuracy found in such works as the Alphonsine tables were publicly confirmed to be very much insufficient for the task at hand. Tools and concepts specifically invented to measure the earth, here I have often mentioned trigonometry, were instead aimed at the sky and found both immediately valuable and promising. In the course of this work
observers found mistakes, made new devices, refined their data, or seemingly, threw it out altogether if they thought it less than valuable.

With these tools, the nova’s location beyond the Moon was quickly certified by the most seasoned observers across the continent. That this conclusion was derived and accepted by the inheritors of generation after generation of scholars who had been trained to recite every reason which insisted that the superlunary sphere was in many ways fundamentally physically different from the world they knew on earth, is a key measure of just how far that entire logical construct had been pushed aside.

Their most effective intellectual tool, the idea and geometric logic of parallax, on the other hand, was certified by all the grand master mathematicians of Europe since Ptolemy. No source I have examined even hinted that this method of determining distance was in any way inappropriate or flawed. This suggests that the natural philosophers of the day, confronted with the nova’s contradictions, believed strongly enough in the basic ideas of some of their intellectual inheritance to trust in its premises: the logic of Euclidean geometry and elementary mathematics had allowed the observers of nature to override a central premise of received knowledge.

For the majority of observers, the star was as all others in the heavens were except that it changed colors and came and went. Why might it change colors? Could it have been there always and only hidden from view? Have there been other stars that have come into view and disappeared in such a manner? What did it mean that the star faded away rather than just disappeared from one day to the next? Almost all observers ultimately came to agree that it was not a comet; no one saw a requisite tail, few thought that it was below the moon, as had Aristotle posited all comets and the Milky Way must
be. If it had truly left, would it come back again? Where exactly did it go? If Ptolemy’s parallax had been so successful, nevertheless, the star’s departure did leave its many investigators with numerous half-answered questions that only told them that some part of their received beliefs were somehow fundamentally wrong. Copernicans, the few to be had such as Thomas Digges, were equally frustrated. One would think that such a unique and unparalleled event should offer some clue or bit of evidence that would come to the aid of their cause. The nova provided no such assistance.

As a parting gift, the nova did force upon Western natural philosophy even more questions they could not possibly answer with the tools they then possessed. Again, the traditional corpus of received theory was searched and found wanting. True to the basic tenets of modern science, one set of conclusions simply led to more questions, and not, as one might hope, a necessarily complete set of logically derived facts, as unsatisfying as that was bound to be.

Ultimately, since the nova’s very existence did challenge standing theory, what exactly was to be made of that theory altogether? The nova was just a small light in the heavens, a place certainly filled with many stars. But those heavens had been, in the minds of almost all who had struggled to grasp its mysteries, reasonably well understood. After 1572, astronomers could not view the celestial world in the same way. The arrival of the new star was certainly not the first event to make the tower of classical learning shake at its foundations. Much in the way of intellectual shaking had come from the voyages of discovery to cause Aristotelian and Ptolemaic geography to seem flawed to the point of uselessness. The heavens had remained the domain of the eternal however, cold and distant and unchanging, as God had made it and, it seemed, He insisted it should
be. If the nova proved that the heavens were mutable, even in such a small and ephemeral way, what was to be made of those parts of the Philosopher’s tower as of yet untouched? For cosmographers plying their craft after 1572, the universe had become a realm of the mutable, like the sub-lunar sphere that they inhabited and worked to know. Now the heavens were a region where historical change occurred, and records could be kept of this change. Natural philosophers henceforth had other things to think about, when they turned their attention to the heavens, than just trying to keep track of the endless motions of the planets. If “things above” were now more like things here on earth that had previously been imagined, it now seemed possible, everyone seemed to agree, that man’s intellectual tools could construct laws which applied there equally as well as on earth. The same ideas that created the modern science of cartography and geodesy after all, had decisively proven their worth in the examination of the nova.

Few modern writers have chosen to consider its effects after the star disappeared from view. But its observers (and their intellectual descendants) could not disregard it. As an historical event, it remained in the minds of astronomers and was added to the corpus of natural phenomena to be explained, where it remained after the comet of 1577 and the novas of 1604 and 1608 came and went.

Three years after the nova faded from view, the world was treated to the arrival of that comet. Unlike its predecessors, it would be observed by people who had far more subtle and fluid concepts of celestial matter that they had had just a few years before. Despite their observers’ efforts at parallactic measurement, the comets of 1531 and 1556 were by and large deemed to be well inside the boundary of the corruptible, terrestrial
world. In any case no one had made any definite conclusions. In direct contradiction of that tradition the visitor of 1577 was immediately placed in the celestial realm by the very astronomers who had witnessed the nova. Little protest was made.238

Its artistic life continued: it appeared in the pages of the first modern star map, the *Uranometria* of Johann Bayer, published in 1603 using a manuscript version of Brahe’s measurements (see illustration on page 47). There it can be found in the neighborhood of Cassiopeia, a bright object next to the traditional painted image of the queen, and more objectively, its position marked by the coordinate system described and used by Tycho and his contemporaries, the new traced upon the old. It was thought still worth throwing in to an illustration of the constellation Cassiopeia by the editors of a celestial atlas printed in 1748.

Johannes Kepler, who had worked as Brahe’s assistant before the Dane’s death, and had inherited much of his stellar data, rushed to publish his own *Nova stella*, after the appearance of the new star of 1604. Kepler had no problem using the records of the first nova as a “forum for his wider Copernican project.” 239 In precisely the opposite way in which Tycho had concluded that the star could not have been moving away from the earth, Kepler insisted that it had. Its dimming over the months of its existence, and the fact of the lack of any discovered parallax, proved to him that the nova had moved an immense distance through the cosmos, and that therefore that cosmos must be far larger than commonly accepted. The 1602 *Progymnasmata* contained Tycho’s lengthily reasoned rejection of the physical existence of the 300,000 earth radii that his calculations had required on order for the star to have been in motion away from its earthly viewers.

Kepler in 1605 judged that 34,077,066 and 2/3 Earth radii were required to explain the dimming of the nova, a distance he had no trouble accepting. The universe thus being that great a size, might easily accommodate the orbit of the Earth, explain the lack of stellar parallax and render absurd the possibility that so large a set of celestial spheres could rotate around the earth once every day.

Galileo used the evidence of the nova to further the destruction of the Ptolemaic universe in the second and third day of his *Dialog Concerning the Two Chief Systems of the World*, published in 1632. Galileo Galilei, *Dialogue Concerning the Two Chief World Systems*, Stillman Drake, trans. and ed., (New York, The Modern Library, 2001): 317, 326. There, in order to tie in the celestial events of the age with the new cosmology, he discussed in detail the parallax results of eight of the observers I have mentioned here. Upholder of the traditional cosmos, Jesuit scholar Giovanni Riccioli still referred to its arrival with interest and curiosity in his, probably the last, great defense of the Aristotelian world model: *Almagestum novum*, published in 1651. By that year, Riccioli knew he was fighting for a mostly lost cause, in part because of the now commonly acknowledged existence of novas. For him, the acceptance of such supra-lunar phenomena led directly to the implication that the heavens must be made of more than one immutable material. If, as he speculated, the planetary spheres were made of fire and that of the stars, water, one might imagine that novas could be the results of the mixing of two elements in the boundary region between the two. In allowing for the existence of change in that previously never changing realm, Riccioli’s explanation made good use of Aristotle’s physical models, and thus made them relevant to the discussion for just a bit longer.

Isaac Newton, perhaps the last commentator to actively take part in the examination and discussion of the nova, responded to Cornelius Gemma’s opinions in his *Principia*, first published in 1687. If Newton agreed with Gemma’s (decidedly minority) view that the new star was in some way related to comets, it was in order to further his own theory that the nova of 1572, along with the other, more recent examples, were products of collisions between dissipated stars (having exhausted their supply of fiery “vapors” and were therefore no longer visible) and comets, which when hitting such stars caused them to burn brightly again for a short time. Gone in his explanations of the bright object of 1572 were any hint of the theories of physical causation as they had been understood throughout the 2000 years of natural philosophical study before the *Principia*; replaced by only motion in a void.

The scholarly and literarily inclined that concerned themselves with such matters spent much of the century after 1572 attempting to connect the star’s arrival with current events here on earth. Kepler, an acute critic and student of Tycho, who had also read and appended the *Progymnasmata* in the early decades of the seventeenth century, though he seems to have paid less attention to the astrological aspects of Tycho’s compilation that its more philosophical conclusions, did note that “if the star did nothing else, at least it announced and produced a great astronomer.”

While he was undoubtedly aware of recent efforts of people like Wilhelm IV to re-catalog the stars and built large accurate instruments before the arrival of the nova, that “great astronomer:” Tycho Brahe, first encountered the serious technical challenges that

accurately mapping the heavens would mean overcoming during the course of his observations in 1572 and 1573. Already quite an experienced mechanic, the 26 year old nevertheless struggled to achieve what he conceived as a sufficient level of accuracy in his measurements of the star’s position. Nothing at hand would suffice for reference: not the stellar lists of Ptolemy, the predictions of the Alphonsine tables, nor the recorded measurements of his century’s best observers, Nicolas Copernicus included.

The Dane seems not to have been so trusting even of his nearer contemporary’s work. The observation of the nova was his first prolonged act of astronomical research; it informed his outlook for the remainder of his long and productive career. From this experience, by his own confession, came the inspiration which led him to dedicate his life, funds and energies to the construction of his observational complex Uraniborg, and a score of evermore accurate observational devices with which to measure and catalog the heavens. In the posthumous publication of his *Astronomiae instauratae progymnasmata*, Brahe showed himself to be still fascinated by the new star to the end of his life, devoting chapters to the letters, publications and theories of his fellow observers, and to their original measurements; of which he seems to have dedicated much of his time reviewing and refining. It has not been lost on later generations of his readers that, like the Hipparchus of Pliny’s tale, Tycho, inspired by a strange apparition in the heavens, went on to create a true image of the celestial world, a more accurate map, with which later generations would come to better understand the workings of the universe.

So, to look into the events surrounding the appearance of the nova, I would like to suggest, is to see a far broader picture of the scientific age in which it arrived than has
been traditionally painted. The nova, in the end, could also be an organizing principle for historians who lived centuries later, across the divide marked by the birth of modern science. To observe the observers so to speak, is, in the nova’s case, to come across a very broad and complex set of social relations that belie the notion that the age was, as one might sometime imagine, dominated by just a handful of revolutionary thinkers, whose works all bear evidence of their intellectual debt to Copernicus, and very little else.\textsuperscript{244} Contemporary accounts of the new star by its observers mentioned the Polish astronomer rarely if at all. And when they did, then almost always it is in relation to his observations alone, not in order to take up the banner of heliocentricism. For natural philosopher in the years of the nova, the ones who look to us today to be the most energetic, talented and discerning, Copernicus was not the great “Revolutionary” that later generations seemed to need to make him. At that moment in time, he rated with a rather large assembly of authors which included Aristotle, Ptolemy, Manilius, Aratus, and Peter Apian, Cicero, Regiomontanus, and the entire list of later Christian authors, poets and prognosticators that many educated and wise figures were sure bore the weight of authority on the subject. Natural philosophers who sought to understand workings of the entire universe, terrestrial and celestial, were far more likely to be inspired by the unity and utility of the various branches of cosmology, than a difficult and abstruse theory about something that couldn’t be proven anyway. As pregnant as were Copernicus’ theories from the perspective of later generations, they bore almost no bearing what so ever on the intellectual efforts of those who sought to understand what or where the nova was. The new star had its own effects on the beliefs of its viewers, and those were to last

long after it finally faded from view. With this in mind, it is incumbent upon historians of
sixteenth century natural philosophy working to understand the dynamics of intellectual
evolution to count works like Tycho’s *Progymnasmata* and the *Dialexis* of Hagecius,
Digges *Alea seu scala* and Heronimo Muñez’s *Libro de la cometa*, as, at least in sum,
equally important records of the reformation of the science of astronomy as is
Copernicus’ *De revolutionibus*.

Those who wrote these books, who pursued the investigation of nature in 1572, were
quite well aware of the project of science as later generations would come to define it: to
understand nature, even if they did not have a firm philosophical doctrine or sure
techniques with which they might guide their researches or describe the boundaries of
their intellectual wanderings. The works of Bacon and Descartes, Galileo and Kepler
were decades away, but the nova’s observers, it seems clear, didn’t need to be told about
the ideas projected in the seminal texts these men produced. They made observations,
gathered numerical data, proposed theories based upon what they had seen and what they
understood the laws of nature to be, and were fully cognizant that they were forced to ask
questions that they had no way of answering even with their best tools. For whatever
were the motivations that sat foremost in their minds, the majority of the new star’s
observers were perfectly willing to toss out time honored tradition with few or no serious
reservations at all. Rather than see this as a problem, one senses the excitement of new
possibilities in their words. Their obviously strenuous efforts to gather data is
symptomatic of the desire to know, and also, of a knowledge of the potential value of
new discovery, the likes of which the age had seen quite a few.
Finally, to reflect one last time upon the age’s more well known (today) astronomical controversy, it is fair to say that the nova’s observers were to a man well aware of the central discrepancies between the Ptolemaic and Copernican theories. They commented upon and referenced both often enough in the letters they wrote throughout their careers. Few seemed to be bothered by having to face two sets of models when thinking about how the universe worked, however. This, I suggest, is because as theories go, in the late sixteenth century it didn’t matter that much which one was correct. Neither forced astronomers to see the universe in a particularly different way. The nova did. It was after all, not a theory; the light from ten thousand light years away shone down on Earth for everyone to see. Its visit went a long way in pushing an ancient and revered theory to its end however, and the astronomers and natural philosophers of the age were ready to do just that.
Fig 25: the nova today (now named SN 1572), recently seen by the public on the front page of the October 5th, 2011 New York Times.
Appendix A
Mathematical Astronomy in the Century before the Nova: Instruments, Pictures and Diagrams

In this thesis I have described in some detail the literary evidence which we have about the nova of 1572. Through the course of my research I have discovered that there is a treasure of observational data and recorded experiences, a sizable fraction of these coming from people we know to have been some of the best astronomers of the day. Through these books, letters and reports, I have been able to piece together a description of the response the nova engendered among the community of educated and professional natural philosophers that made up the age’s body of scientific expertise and authority.

Often one may read these records, and from them only vaguely sense the nature of the practice of observational astronomy in the decades immediately preceding the nova, and as it was understood by the nova’s observers in 1572. On occasion the modern reader can hear in the voices of these authors some unease with the received ideas about the technical practice of astronomy they used as tools to understand what they were observing before the arrival of the mysterious star in the heavens near the constellation Cassiopeia. Much discomfort there had been, however, with the science of astronomy throughout the sixteenth century, and other aspects of my research – beyond the reading of original sources and accounts of the new star, have been instrumental in shining a spotlight on its causes.

In addition to the collection of writings about the nova that I have examined, there is another body of printed literature which plays directly upon and provides evidence for my study. This is the rather large collection of publications and other communications concerning observational astronomy throughout the sixteenth century and before; beginning with Regiomontanus’ publication of the *Epitome of the Almagest*, and continuing on throughout the entire period, to influence astronomers Wilhelm IV, Tycho Brahe and ultimately, Johannes Kepler and those who he inspired in later ages. I have touched upon these publications in chapters two through four, only insofar as I felt necessary to make the points I felt necessary to make.

From this evidence however, it is safe to infer that, around the later years of Regiomontanus’ career (one hundred years before the nova’s arrival) observational astronomy, geography and cartography, the collection of sciences that then made up the study of cosmology, began to undergo a profound evolution. While these had always been influenced by mathematical principle and disciplined observation, in the sixteenth century, mathematical analysis and observational technique moved to the center of concern for cosmographers. In the light of the newly made discoveries, and equally importantly, the effects of the matured discipline of trigonometry an artistically inspired geometry, the Ptolemaic and Aristotelian traditions so heavily relied upon by traditional natural philosophers who worked in these fields was found to be in some ways flawed.

The realization of the weaknesses of their central rational assumptions caused cosmologists to reconsider their tools and their methods of analysis. The study of natural philosophy in the sixteenth century is in part the study of the “retooling” of the methods of mathematical observation and analysis in response to those perceived weaknesses. The nova, exposing one of the great, perhaps fatal, weaknesses of the traditional physical understanding of the universe, also produced its own effects upon the technical end of astronomical theory.
Here, I will review some of the visual evidence and contemporary writings concerning that long evolution. I have found that there exists within the easy grasp of modern researchers a vast body of visual evidence with which to describe how astronomy (and cartography) was done, and how it was changing in the decades before the nova. The following are illustrative of the changing perceptions and perspectives of astronomers in the century before the nova’s appearance.

1) The Platonic Tradition

Figures 26 – 8 above are three examples of Platonic mathematical theory; left: the only published illustration by Leonardo Da Vinci (1494), middle: from Kepler’s Mysterium cosmographium (1596), right Albrecht Durer’s print “Melancholia” (1514).

With the translation and publication of Plato’s dialogs in the 1470’s, there arose a classical alternative to the now centuries old Christianized Aristotelian tradition that made up the core of the European university education. Images which allude to the newly translated literature and its potential meanings were commonly produced on the new printing presses of the republic of letters. Exactly what these might mean in a practical sense for astronomers seems less than clear however.

While most who concerned themselves with the subject might easily understand that the various phenomena of nature were made up of hidden numbers, geometric shapes and mathematical relationships, deriving some definite conclusions about those numbers and shapes was another thing all together. As powerful and attractive as this idea was, as a proposition, it seems to have functioned best as a sort of philosophical banner. During the sixteenth century, this standard was waved about much, but only slowly and haltingly did it lead any one to any great conclusions about nature and the universe. Below is an interesting adaptation of the platonic solid, as either a tool of astronomy, or a purely symbolic device.
Fig. 29: This illustration is particularly telling in that the artist points to two very different ways of understanding the mathematical nature of the universe. While observers literally rest (in this case one steadies his hand) their theories and models on the Platonic ideal of a universe whose structure is based upon geometry, they search the heavens using far simpler tools: quadrant, cross staff and even one’s hands will do in a pinch. It is to me not obvious as to what the dodecahedron might do for the observers in the picture, other than symbolize Plato’s and the artist’s belief in the primacy of geometric shapes in *physis*. Copernicus among many others was certainly powerfully influenced by the age’s Platonic revival. Perhaps in the same way; the philosophical defense of his work in book one of *De revolutionibus* makes reference to platonic ideas, the remainder of this long book falls back upon the more practical, result oriented approach presented by Ptolemy in his *Almagest*, Peter Apian in his *Astronomicum caesareum* and Regiomontanus in his book on triangles.

2) Practical Approaches

For all its flaws, and there seemed to be a growing number of these detected throughout the centuries before and after Regiomontanus’ death in 1476, the Ptolemaic / Aristotelian model of the universe continued to be held in the highest esteem by educated Europeans. This seems to have been for several reasons. It was certainly authoritative; even though Ptolemy’s methods of prediction were, it was becoming ever more clear, in some way flawed, there was
simply no other means of producing anything like a vaguely numerically accurate model of the motions of the planets. It had been (almost) seamlessly sewn into the fabric of the Christian cosmos by scholars like Thomas Aquinas, and accepted by the western church’s finest scholars for centuries.

This being said, quite a few professional astronomers working in the decades after Regiomontanus’ death were perfectly willing to challenge some of its assumptions. Much more was suspect that faulty ephemerides. Regiomontanus himself, for instance, had suggested that observers attempt to locate the actual place of comets in the universe; Aristotle’s cometary theory being high on the list of mysteries not well explained by the Stagerite, and increasingly seeming somehow incorrect.

Fig. 30: Above, we see contemporaries using the best tools at their disposal in an attempt to find the location of the comet of 1533. The artist depicts an observer, note: a man with a sword, symbol of aristocracy, not scholarship, attempting to determine the location of a comet. He relies here not upon any books or other sources of knowledge, but only his powers of observation and his cross-staff.

3) Advances in Mathematics

The century after the death of Regiomontanus also saw the growth of a mature form of trigonometry, especially after the publication of his own text *De triangulis*, some fifty four years after he himself had passed away.
Figs. 31 – 32: Above are two commonly seen illustrations depicting cosmological and mathematical concepts from the fifteenth and sixteenth centuries. Fig. 33: Below, a diagram from a medieval hand copied version of Ptolemy’s *Almagest*.
Fig 34: Though Ptolemy’s great work on mathematical astronomy was seen as the central work on the subject, it is likely that only a few ever had the opportunity to actually look at and study a copy. Here is a page from the first edition ever printed, and therefore put into circulation in any quantity, in 1515. It happened to be printed from that translation first made by Gerard of Cremona, sometime in the second half of the 12th century. Most who read it thought it was a flawed translation at best.
Fig 35: The first page from Regiomontanus’ fifth book on trigonometry (first published in 1533) which deals with spherical Trigonometry.

Fig 36: From Reiner Gemma Frisius’ *Libelus locorum*, the first book to describe the uses of trigonometry as a tool in land surveying.
4) Astronomical Interests

One of the things that most impressed me in my research might be described as the breadth (and varying depths) of popular interest that Europeans of all educational levels showed towards the practical end of astronomy and also, in at least attempting to come to some understanding of celestial events. This can be seen in the large and rather accessible collection of astronomical artifacts that have survived from the age.

Instruments designed to measure the heavens appear throughout the artwork of the age. Below and to the left (Fig. 38), geometors measure the size of the universe in Pieter Breugel’s 1551 print “Temperance.” Right (Fig. 39): medieval women study astronomy, their tools being pretty much the same as Breugel’s mathematicians.
Above: Hans Holbein’s “The Ambassadors” (1533), displaying astronomical instruments as status symbols as well as cryptic ciphers.
Below, a late sixteenth Century artist depicts the Greek astronomer Aristarchus pondering the centrality of the Sun.
From the images I have printed above, all sixteenth century astronomical instruments, it can be seen that, at least in some cases, much time, interest, creativity and money was spent upon
astronomical instrumentation, even if we consider that some of these devices were made as “show pieces,” and might never see the dark of the night sky as a practical tool.

In looking at these observational tools, one begins to see certain design patterns emerge. For one, these devices are almost all hand held. While making it easy for the observer to transport them around, and cheaper and easier to manufacture, it means that they would have been fairly unsteady. Much in the way of accuracy must have been sacrificed in this way. In no image I have seen made before the 1560’s, does any contemporary observer have any device that is more than two or three foot in size. For all their cunning use of geometry and trigonometry to provide solution to their efforts to find stellar positions, by virtue of their small size, any data distilled from such measurements must have been inaccurate.

Below I have reproduced an exception. This 1559 print is particularly instructive however: by the fact that he was given a crown to wear, the artist has indicated that the observer is none other than Ptolemy himself, using a device described in the *Almagest*, not a contemporary to the nova.

![Figure 48](image1.png)  ![Figure 49](image2.png)

Whether he knew it or not, however, the artist created an illustration that contained some of the secrets of making the necessary improvements upon the accuracy of observational astronomy. For what ever reason, by the 1560s, some astronomers began to experiment with finding ways of increasing the accuracy of their instruments. Making accurate instrumentation is no cheap endeavor at any level however. What were to become the solutions that designers had put in place by the end of the century made the small hand held device obsolete. Serious observational research could only grow in expense, and decline in popular utility.

5) More Effective Approaches

By the 1560’s (just in time for the nova) at least two independent sets of individuals and their associates began to develop solutions to the problems faced by current observational technologies. These were the Landgrave of Hesse, and the college student Tycho Brahe. Wilhelm was a wealthy member of the nobility who had been inspired to study astronomy as a child when he read Apian’s *Astronomicum Caesareum*. Wilhelm hired craftsmen to build instruments and clocks which he had designed. We know much more about his younger contemporary Tycho
Brahe, and his efforts to improve the accuracy of his instruments. In the 1560s Brahe worked to bring to reality the theories of scale and accuracy others had theorized about. Below is an image of the largest instrument of the age, the nineteen foot quadrant he had built for the wealthy merchant Paul Hainzel.

Fig. 50

This technological evolutionary tree bore much fruit, specifically, the accurate measurements of the nova that made them so sure it lay beyond the Moon. This branch only came to and end after the invention of the telescope. On the opposite page is the astronomer Hevelius and his wife Elizabeth using an instrument similar to Hainzel’s, sometime in the mid-seventeenth century.
Few in 1572 had the money or the inspired creativity to produce even lesser versions of the nova sextant that Tycho brought to bear on the star. Most must have had to feel content with alstrolabes, cross-staffs and whatever else might be at hand. The dearth of genuinely accurate instruments, however, helps to highlight for us another important aspect of the astronomical practices of the age: that of community and common action. If in 1572, only two or three groups of observers could make any truly accurate measurements of the nova’s positions, dozens of less well endowed observers could and did work in common and made an effort to develop consensus about what they were seeing. My thesis has been in part about the failure of just that consensus building effort. Having not been successful in that matter however, did not preclude their effort from being useful to their contemporaries, if only as a catalyst to debate.
Wilhelm IV, Landgrave of Hesse-Cassel. Behind and to the left and right are the best contemporary depictions of his equipment and his observatory we have. The figure at the lower right is thought by some to be Tycho Brahe.
Appendix B:
The Nova’s Observers
Found in Either Their Own Written Works or
the Commentaries of Others.
Note: As well as those named here, Brahe, in his *Progymnasmata* lists several authors under the term “anonymous”; they are described only as “German.”

1) **Apian, Philip** (1531 – 1587), Son of Peter, professor of mathematics at University of Ingolstadt, and mentor to Michael Maestlin (see below) Tycho, TBOO, p.157, v. III.

2) **Benedicto, Iohanne Baptista**, “Patricio Veneto” a correspondent of Hanibal Raimundus, Tycho, TBOO, p. 250, v. III.

3) **Beza, Theodore** (1519 – 1605), Successor to John Calvin in Geneva, wrote a poem about the nova included in Cyprian Leovitius’ work.

4) **Brahe, Tycho** (1564 – 1601), Concerning the nova: Tycho Brahe *Opera Omnia* TBOO, vols. 2 and 3, vol. 15 and *Nova Stella*. All contain his criticisms of other’s works as well as his observations.


6) **Camerarius, Elias**, Doctor of Mathematics at Frankfurt; *Observatio et descriptio novi siderius, quod in principio Octoberis Anno Christi 1572 Forma stella prima magnitudis apparuit*, Hellman, Brahe, TBOO, p. 205 v. III.

7) **Camden, William** (1551 – 1623), Educator, elected Master at Westminster School in 1575, Wrote “Britania” in 1586, in which he mentions the nova and his countrymen’s responses.

8) **Cantzlero, Ricardo**, “Mathematico,” Tycho TBOO, p.184, v.III.
9) **Clavius, Christophe** (1538 – 1612), Jesuit Mathematician and a founder of the *Collegio Romano* in Rome, member of Gregory’s calendar reform committee, best known in his life time for his translating Euclid into Italian. 1581 commentary to Sacrobosco’s *De sphaere*, page 601 contains his comments.

10) **Cyprian, Leovitus** (1514 – 1574), Professor of mathematics and astronomy in the Palatinate. Wrote ephemeris in 1564, published *Tabulae eclipsum* based on Reinhold’s *Prutenic Tables*. Met Tycho in 1569. In Cornelius Gemma, *De nova stella iudicia duorum praestantium mathematicorum* 1573, Tycho, TBOO, p. 218, v. III.

11) **Chytraeus, David** (1530 – 1600), Lutheran theologian at the University of Rostock. In Tycho, TBOO, p.217, v. III.

12) **Covarius, Franciscus Vallesius**, Physician to Philip II. Tycho, TBOO, p. 87, v. III.

13) **Dee, John** (1527 – 1609), English mathematician and confidant to Elizabeth I Tycho, p. 203 TBOO, v. III. Wrote *Parallaxae Nucleus*, as companion piece to Thomas Digges’ *Alae seu Scala*. Also: *On the Marvelous Star in Cassiopeia, Sent Down from Heaven all the Way to the Sphere of Venus…*, 1574 (now lost), and *Hipparchus Redivius* in 1573 (now lost).

14) **Digges, Thomas** (1546 – 1595), English Mathematician, son of Leonard, and protégé to John Dee Tycho, TBOO, p.167 and 187, v. III; *Alae seu scala mathematicae*, published in spring of 1573, also thought to be author of: “Letter sent by a gentleman,” also in 1573, in response to Jean Goselin’s *La declaration*.


16) **Frangipanus, Cornelius**, Commented upon by Hagecius in his *Dialaxis*, p.27, Tycho TBOO, p. 254, v. III.

17) **Gemma, Cornelius** (1535 – 1578), Son of cartographer Rainer Gemma Frisius, professor of mathematics at Louvain. Tycho, TBOO, p. 67, v. III. Author *Stella perigrinae*, 1573, which was appended to Leowitz, Postel and Hagecius. Published “*De naturae divinis characterisms*” in 1575. Further comments can be found in his *De prodigiosa specie naturaque* (vol. 2), 1578.

18) **Giutini, Fransesco**, Published his comments in a later commentary on *De sphere.*


21) **Hagecius, Thaddeus** (1525 – 1600), Court physician to Maximilian and Rudolph II. Tycho, TBOO, p.19, also 177, v. III, Hellman. Published *Diallelis de nova et prius incognitae stella*, in Prague, in 1574, which included works of Gemma and Munoz.

22) **Hainzelius, Paulus** (1527 – 1581), an Augsburg patrician, he helped Tycho to build a 19 foot quadrant in the middle years of the 1560s. “Consul to the Emperor” Tycho, TBOO, p. 48, v. III.

23) **Homelius**, Tycho, TBOO, p.184, v. III.


25) **Maestlin, Michael** (1550 -1631), First, assistant to Phillip Apian (see above), then replacing him as professor of mathematics at Tubingen (1580), Lutheran minister, teacher and lifelong friend of Kepler. Tycho prints his entire report, TBOO, p. 58, v. III.

26) **Maurolico, Francesco** (1494 – 1575), Benedictine monk living in Sicily. Wrote a “Cosmographia” in 1543. Head of Sicilian mint, master of fortresses, professor of mathematics at University of Messina. Thought to be first nova observer in any written account. Source of Clavius’ information about the nova. Translated by Hellman: “Murolico’s Lost Essay on the Nova of 1572”.


29) Peucer, Caspar (1525 – 1602), Lutheran Theologan and scholar, son in law of Philip Melanchthon. Wrote popular astronomy text Hypotyposis orbium coelestrum, which relied upon the Prutenic Tables (1568 and 1573). Tycho, letters between Peucer and Wilhelm, Landgrave of Hesse-Cassel, Wolfgang Schuler, and others, TBOO, p. 49 and 113, v. III.


31) Praetorius, Johannes (1537 – 1616), Talented instrument maker and professor of mathematics at Wittenberg. Said to have taught Christoph Rothman, who later worked as “mathematicus” for Wilhelm IV (see below). Tycho, TBOO, p.153, v. III.

32) Pratensis, Ioannes (1543 – 1576), Friend of Tycho while they were at the University of Copenhagen. Noted Paracelcian doctor. Tycho inherited his Almagest after his death. Tycho, TBOO, p 93 and 97, v. III, also two of his letters are included in the Stella Nova.

33) Pridianus, Paulus, Commented upon by Hagecius in his Dialexis.

34) Raimundus Veronensis, Annibal, Tycho, TBOO, p. 233, v. III, commented upon rather negatively by Hagacius in his Dialexis, p. 21 (“malus logicus et ineptus astronomicus” [p. 25]).


36) Reisacher, Bartholemew, Professor of Mathematics at Vienna, Tycho, TBOO, p. 45 and p.259, v. III.


39) Schulteri, Bartholemeo, Tycho, TBOO p. 184, v III.


42) **Wilhelm, Landgrave of Hesse-Cassel** (1532 – 92, pictured above), Member of German nobility, talented astronomer and designer of astronomical instruments. Scientific inspiration to Tycho Brahe, Tycho, TBOO, p. 6, v. III. As his assistants he employed:
   1) Christoph Rothmann, “mathematicus,” who later become well known to Tycho Brahe, traveling to Uraniborg in the 1580s.
   2) Joost Burghii, a mechanic who had a wide reputation for building complex clocks. After he left Wilhelm’s service he went to work in Prague for Rudolph II.

43) **Witkind, Herman**, Professor of mathematics at Heidelberg. Mentions nova in his 1577 commentary on Sacrobosco.

44) **Wolf, Hyronimous** (1516-1580), Student of Melanchthon and German Humanist, Tycho, TBOO, p. 50, v. III.

45) **Zuniga, Diego** (1536 –1597), Taught at university of Salamanca. A supporter of Copernicus, had the distinction of being placed on the Index along with Copernicus for his “Commentary on Job,” in 1616.
Appian, Peter, (ed. Gemma Frisius), *Cosmographica, sive, descriptio universi orbis*
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