New Heavens and a New Earth

The Jewish Reception of Copernican Thought

JEREMY BROWN

OXFORD
UNIVERSITY PRESS

Introduction

In the early years of the twenty-first century, Rabbi Shlomo Benizri, a former minister in the Israeli government, published a comprehensive textbook on the Jewish calendar entitled *Hashamayim Mesaprim* (*The Heavens Proclaim*).[1] Most of Benizri's work covered the complex mathematical and astronomical foundations that determine the structure of the lunar-based Jewish calendar, and the last part of the book described the nature of the solar system. In this section, Benizri concluded that despite nearly five hundred years of scientific and astronomical evidence to the contrary, the Sun revolves around the Earth. Although Benizri was educated in traditional Orthodox *yeshivot* (the higher academies of Jewish learning) and never attended university, his book made use of many modern scientific instruments and discoveries. It reproduced high-resolution telescopic images of the surfaces of the planets (including those sent from the famous Viking 1 project) and described the composition of the atmospheres and surfaces of the planets using data from NASA's solar explorations. And yet Benizri, who was once Israel's minister of labor and social welfare, could simply not allow himself to believe that the Earth orbits the Sun because, in his analysis, the Bible, the rabbis of the Talmud, and their medieval commentators had all concluded that the Earth was at the center of the universe.

If Benizri's fundamentalist approach seems remote from daily life in America, consider the following episode involving the five-term Republican from the Georgia state legislature, Ben Bridges. In February 2007, Bridges circulated a letter to dozens of other state representatives, in which he directed their attention to websites that provided "indisputable evidence" that evolution was a religious concept dating back two millennia to "Rabbinic writings in the . . . Kabbala." The purpose of this bizarre allegation was to demonstrate that since evolutionary theory, considered by all to be a scientific concept, was in point of fact a religious concept (or, as Bridges put it, a creation scenario of the "Pharisee Religion"), the constitution should prohibit it from being taught in publicly funded schools. Bridges hoped to provide a victory in the ongoing battle being waged by fundamentalist Christians to prevent the teaching

of evolution in public high schools. That the websites that Bridges was publicizing were profoundly anti-Semitic is beyond dispute, but what is of interest to us is the fact that their purpose was not only to fight against Darwinian thought. They also claimed that "…the Copernican model of a rotating orbiting Earth is a factless observation." Representative Bridges was not alone in publicizing the fixed-Earth position. His memo was circulated with a letter of support from the second most senior Republican politician in the Texas House of Representatives, Warren Chisum, who served as chair of the Texas House Appropriations Committee.[2]

Although they were separated by thousands of miles, had no common language, and followed quite different, indeed irreconcilable belief systems, both politicians Benizri and Bridges would no doubt have been united in their fight against the common enemy, the Copernican credo.[3] The positions that Rabbi Benizri and Representative Bridges—one an ultra-Orthodox Jewish member of the Israeli Parliament and the other a fundamentalist Christian member of the Georgia House of Representatives—share with regard to Copernican thought are shared by very few others from their respective faith traditions. Yet both gave a public voice and wide exposure to a debate that began nearly five centuries ago and involved some of the most talented religious thinkers of the times. This debate continues to have an impact on how we view the interaction of science and religion.

Over the last several years, there has been a renewed interest in the way in which scientific knowledge and religious thought interact, and there are a number of reasons for this. There was tremendous public attention paid to the 2005 court case of *Kitzmiller v. the Dover Area School District*. This case resulted from an attempt to have intelligent design taught as a scientific principle alongside the theory of evolution in public schools.[4] In the years that followed, many authors with impeccable scientific credentials weighed in on both sides of the question of God's existence.[5] The *Dover* case demonstrated some of the difficulties that religious believers have with Darwinian thought. But a more profound reason lies beneath the renewed interest in understanding the conflict and coexistence of science and religion, and it involves the suggestion that, contrary to religious teachings, we may not, after all, have the freedom to choose between good or evil.

Over the last fifty years, advances in neuroscience have raised deep and weighty questions about what it means to think and act with free will. We have come to understand that our states of mind are more determined than we had ever imagined. Consider, for example, the common affliction of depression. We now have an understanding of its biochemical basis, and as a result, it is possible to successfully treat this disease with medication. Furthermore, the genetic basis of a vast number of other disorders once classified under the

general and imprecise umbrella of "mental disorders" has been determined. It would seem that the way we feel or interact with others is not volitional, but is in large part predetermined by the genes we inherit. This genetic basis of much of our behavior may even affect our ability to make moral decisions. There is evidence that criminal behavior may not only be the result of personal choice, but may be genetically programmed from conception.[6] All this evidence suggests that perhaps we cannot act otherwise than we do. The religious thinker must grapple with the question of what this implies for concepts that are central to the major world religions, such as freedom of choice, sin, and repentance. What role do Yom Kippur and Lent play in seeking God's forgiveness if we are never able to do otherwise than sin? What becomes of the concept of reward in the afterlife if our actions on Earth are never freely made? It is questions like these that are the basis of a new interest in the way in which scientific discoveries affect religious sensibilities.[7]

The question of how a religious tradition responds when faced with scientific evidence that challenges its basic tenets of belief is not new. Whether it is the question of free will and scientific determinism, Darwinian evolution and the biblical account of creation, or the heliocentric theory and the centrality of the Earth in God's universe, religious traditions have been challenged by science for close to half a millennium.[8] Various attempts at the synthesis or rejection of these conflicting worldviews have been made for just as long. Throughout this period of time, the religious debate over Copernicus's heliocentric theory has been overlooked as a model of the way in which religious thought may initially contradict scientific discoveries, only later to reach a period of accommodation and understanding. The history of Copernican thought and the way in which the Catholic Church contested it have of course been well documented. What seems to have been largely ignored, however, is the *process* by which Judeo-Christian faiths made their peace with what was originally regarded as a subversive or even heretical claim. For those who study how religions reject, accept, or absorb new scientific discoveries, the history of the Jewish debate over Copernican theory is a paradigm that deserves much greater study among historians of science and religion, because there are several aspects of the heliocentric theory that make its study uniquely valuable.

First, for many religious thinkers, the heliocentric theory is diametrically opposed to the literal meaning of the Bible. There can be no more stark a contrast between a scientific and a religious conception of the universe than this. As we shall see in detail in chapter two, in various places the Bible quite literally asserts that the Sun moves and the Earth is stationary. Joshua commanded the Sun to stand still at Gibon. Isaiah prophesied that the Sun's shadow would move back as a sign of forgiveness for King Hezekiah, and the Book of Ecclesiastes opens with a powerful declaration of the Earth's immutability,

declaring that "... the Earth stands forever. The Sun rises and the Sun sets and glides back to where it rises."[9] The Bible has several other verses that describe a universe in which the Earth lies at the center of God's majestic universe. For traditional Jews, Moslems, and Christians, the Five Books of Moses—the Torah—were divinely revealed and transmitted directly to Moses on Mount Sinai, and its text has a divine imprimatur. The rest of the Bible may have been written later, but its authors were all prophets who spoke with the Lord God. From Joshua who conquered the Land of Canaan, to Jeremiah who lamented the destruction of Jerusalem, from King David, author of the Book of Psalms to Isaiah who consoled the people of Israel, all were men whose carefully chosen words carried God's approval. God would not deceive, and his prophets' words could deceive no less. If the Bible described the Sun as revolving around the Earth, that description must also accord with reality. To state otherwise is a direct affront to those who claim that the Bible is the word of God and, as such, contains truths that cannot be denied. There have been other scientific theories—notably the Big Bang theory—that also seem to threaten the word of the Bible. However, these theories are complicated and require a level of sophistication with astronomical physics to fully be appreciated. Perhaps most importantly, they cannot be verified by simply standing outside. The Copernican theory was quite different. The Sun certainly looks as if it circles the Earth, and the idea that the Earth is moving around the Sun is both easy to grasp and counter to our everyday observations. It doesn't take an advanced degree in astrophysics to grasp the heliocentric premise.

Second, for over three hundred years, the heliocentric theory of Copernicus was a theoretical construct only. It differed from other theories we encounter today, such as the theory of evolution or the theory of relativity. Here we should spend a moment to clarify what is meant by a scientific theory. Evolution, for example, has been criticized by its creationist opponents as being "only a theory," by which they mean to contrast it with a scientific *law*, such as Newton's three laws of motion. This claim is supposed to undermine the status of the theory of evolution and place it alongside a number of other possible explanations of how life developed on Earth. In actuality, the theory of evolution has tremendous explanatory ability and is supported by a vast array of evidence from several different scientific disciplines. Those who claim that its status is undermined because it is not described as a law fail to grasp that the word *theory* has several different meanings.[10] It can be used to describe a hunch or a guess as in "here's my theory of why the baseball team played a terrible game" or "that's just a theory; here are the facts." However, the word has a very different meaning when used in conjunction with the word *scientific*. A scientific theory is an explanation of how and why certain observations occur. But as Jerry Coyne has pointed out, it is "much more than just a speculation of how

things are: it is a well-thought-out group of propositions meant to explain facts about the real world."[11] A scientific theory must make predictions that may be tested and falsified. The more predictions a theory correctly makes, the more likely are scientists to be confident that it is correct.

The Copernican model seemed to explain the motions of the planets in far more satisfactory a way than did the previous Ptolemaic model, but for almost three hundred years it was an unproven hypothesis, and not a scientific theory. Now this is not to claim that modern conceptions of what constitutes the scientific method were shared in the first three centuries after Copernicus lived. But soon after the century in which Copernicus published his revolutionary work, it was clear to some that experimental evidence should indeed be brought to bear on the question of the truth of the heliocentric model. For example, in 1674, Robert Hooke wrote that if stellar parallax could be detected, it would be a "most undenyable Argument of the truth of the Copernican Systeme."[12] The hypothetical nature of Copernicus's claim was noted in every first edition of Copernicus's *De Revolutionibus,* for they contained an anonymous apologia in the form of an introduction to the reader. This introduction, known as *Ad Lectorum* (to the reader), was written by the final editor of the work, the theologian Andreas Osiander, and was not authorized by Copernicus.[13] Osiander took pains to point out that far from being a true description of nature, the hypotheses in the book were solely mathematical devices. As such, they could be used as an aid in calculating the location and movement of the planets, but should not be thought of as claiming to reflect reality. Osiander added this introduction to avoid a clash with the Church, and there is no evidence that Copernicus himself saw his heliocentric model as theoretical.[14] But whether Copernicus thought that his model was a description of reality or just an elegant hypothetical construct, the important point is that there was no scientific evidence for its veracity until the nineteenth century.[15] Despite this lack of scientific support, the heliocentric model was clearly viewed as a challenge to the biblical worldview. So for three centuries, Jewish and Christian thinkers faced a challenge from a scientific hypothesis that, while persuasive, was not fully substantiated. During this time, these religions developed varied responses that were significant for the fact that they did not depend on an analysis of a particular experiment. This allows us to study how the religious mind responds to a purely theoretical scientific challenge. Such an analysis is in many ways more rewarding than an examination of the response to a scientific experiment. Experimental evidence may be challenged in ways that theoretical conclusions are not: Are there alternative explanations for the observation? Was the test performed under ideal conditions, and have others indeed verified that its conclusions are accurate? Today we usually view the experimental corroboration of a scientific theory as its ultimate vindication.[16] However, a theory that

is at once scientifically persuasive and religiously troubling and that has yet to be experimentally supported will often require a much more creative analysis by religious thinkers, for they cannot resort to the simple defense of challenging the experimental methodology as somehow flawed.

In these early years of the twenty-first century, the scientific community has formulated an impressive array of theories, many of which have been experimentally verified. Yet there remain some scientific ideas that, although convincing, have yet to be subjected to crucial experimental verification. For those who understand it, string theory (if it is a scientific theory at all) is one such idea, but there are others that more directly affect the religious thinker. As we have already mentioned, notions of genetic or physical determinism have increasingly challenged the religious concepts of free will and hence concepts of reward and punishment.[17] Yet the collective evidence that our actions are often determined, while persuasive, has not been experimentally verified. Consequently, notions of determinism stand in a similar relationship to religious thought as Copernican theory did almost five hundred years ago. The evidence for both is convincing but not absolute, and the implications that each has for traditional religious concepts are far-reaching. The techniques that religious communities used and continue to use to deal with the challenge of the Copernican *theory* are, therefore, likely to be able to teach us much about the way in which these same faith communities can face similar theoretical challenges from the contemporary scientific community.

There is a third reason why the history of the reception of the Copernican theory in Jewish thought is so important for the contemporary debate about science and religion. The heliocentric model has been around a good deal longer than all of the modern scientific theories that are thought to be troubling to the modern religious mind. Darwin's "dangerous idea" is barely two hundred years old.[18] The big bang theory developed from the work of many theoretical physicists and observational astronomers beginning (depending on whom you choose to include) in the early years of the twentieth century. Modern challenges to free will based on the field of neuroscience are a good deal younger still. By comparison, there are almost four hundred years of recorded Jewish responses to Copernican thought. This rich history contains many approaches, some predictable and others novel, from which contemporary scientific and religious thinkers have much to learn. These approaches varied depending on the time, place, education, and religious worldview of each writer, but taken as a corpus of literature, they have left us with much to analyze and study.[19]

There have been several monographs and essays that have addressed the reception of Copernican thought in Jewish intellectual history.[20] The earliest review in English was published in 1977 by André Neher in the *Journal of the History of Ideas*.[21] It set the foundations for later discussions, but his contribution

is limited for several reasons. Neher's analysis intentionally extended only into the eighteenth century and so did not mention many important rabbinic works published later that relate to the Copernican debate. For Neher, the ability of Jewish thinkers to side with or fight the Copernican position indicated "the tolerant environment of their Jewish community." He failed, however, to investigate what theological motives formed the basis of these positions. He discussed several works in which the Copernican thesis was supported, and two in which it was attacked, but overlooked those in which the heliocentric theory was simply ignored. Those scholars who chose to make no mention of the heliocentric theory were making a statement too, and their motives demand analysis. More problematically, many of Neher's suggestions are unsubstantiated flights of fancy. In his analysis, Rabbi Judah Loew of Prague was a relativist, and he imagines the sixteenth-century rabbi to believe that "Ptolemy was right in his time, so why should not Copernicus be right today?"[22] Neher suggests, with no supporting evidence, that Joseph Delmedigo, a rabbi and student of Galileo, was a champion of free inquiry: "Free Galileo, Delmedigo seems to be saying, release him to us; in the midst of the Jewish community he will not be subjected to any trial, we shall not require him to make any retraction, we shall welcome him and honor him like a Rabbi in Israel." Neher is also mistaken when he described *Ya'arot Devash* by Jonathan Eybeschütz as having a "positive attitude towards Copernicus." In fact, and as we shall see in a later chapter, Eybeschütz wrote that the Copernicans had "made fools of themselves . . . and left the world with a lie."[23] Neher's underlying thesis was that "[f]reedom of thought was an integral part of the Jewish conception of science and the world," a conclusion that several later scholars have found severely lacking, and one that ignores the excommunication of Baruch Spinoza as important evidence to the contrary. Neher's contribution opened the field to inquiry, even if many or perhaps most of his conclusions are highly suspect.

In 1983, Hillel Levine published a brief essay that examined not only the Jewish reactions to Copernican thought, but also attempted to place these reactions within a sociological context.[24] Levine criticized Neher's earlier paper as overemphasizing the positive responses to Copernicus and overlooking the "important issues that were at stake in the conflict between cosmological models." Unfortunately, Levine did not review some of the important personalities whose work sheds much light on precisely these issues.[25] A decade after Neher's paper, Michael Panitz reviewed Jewish responses to the new astronomy from the seventeenth to the nineteenth centuries.[26] Panitz offered a far more thoughtful analysis than did Neher, although he also failed to give an adequate evaluation of some of the important thinkers and didn't mention others at all.[27] His conclusion, contrary to Neher's, was that although

most Jews did eventually embrace the heliocentric view, they did not do so as easily as had previously been imagined.

Although these three essays are the sum total written in English exclusively on the reception of the Copernican theory in Judaism, several others touch on this subject even if it is not their main focus of inquiry.[28] For example, there have been several books that have evaluated the contributions of some rabbinic astronomers and men of science.[29] Perhaps the earliest work in English was Jakob Petuchowski's 1954 study of David Nieto, who was rabbi of the Spanish and Portuguese Synagogue in London at the start of the eighteenth century.[30] George Alter reviewed the lives of David Gans and Joseph Delmedigo in 1958.[31] Still later, an intellectual biography of Delmedigo was published by Barzilai in 1974, and Neher's study of David Gans appeared in 1986.[32] No comprehensive study, however, of the Jewish response to Copernican thought has appeared. David Ruderman, the scholar of Jewish history, noted this lacuna when he pointed out that, although the reception of new scientific ideas in the sixteenth and seventeenth centuries has been systematically studied,

> …no such investigation has yet been undertaken with respect to Jewish thought.[33] Such an inquiry into Jewish sources would be important both in assessing the awareness of Jews to the literature and technology of the new discoveries and in evaluating the ability of Jewish traditional culture to assimilate new and contradictory data and assumptions about the physical world. Furthermore, such an examination would offer a comparative perspective in which to view the Christian community's adaption to scientific novelty and change.[34]

It is precisely this investigation that this book attempts to undertake.

An analysis of our topic could be approached in a variety of ways. It is possible to categorize the Jewish responses to Copernican thought by their geographical origin, or with regard to the particular branch of Jewish practice and thought to which their author belonged. We could analyze reactions along a division of accommodation or rejection, or we could do so with regard to the influence of the scientific world on the contemporaneous religious thought. While each of these approaches certainly has its own merits, our approach is generally chronological. Chapter 1 discusses the setting of the Copernican revolution and its challenge to Jewish and Christian thought of the time. Jewish thought, both legal and philosophical, is built as much on precedent as it is on innovation and novel analysis. We cannot understand the lengths to which the geocentric model was defended without first

understanding the talmudic concepts of the natural universe, and this is discussed in chapter 2. Chapter 3 examines the writings of David Gans, who studied with both the astronomer Tycho Brahe and one of the most famous Jewish thinkers of all time, Rabbi Judah Loew, known as the Maharal of Prague. In chapter 4, we learn about Rabbi Joseph Delmedigo, who wrote an important textbook of natural science and was a student of Galileo himself. The next chapter analyzes the writings of the physician-rabbi Tuviah Cohen, who studied at the University of Padua at the beginning of the eighteenth century and later wrote a textbook of medicine called *Ma'aseh Tuviah*. This work—the "best-illustrated Hebrew medical work of the pre-modern era"[35]—contained a section on cosmology, in which the author aggressively described Copernicus as "the first born of Satan." The next three chapters cover other thinkers of the eighteenth century and the start of the open embracement of heliocentricity. Chapter 9 analyzes the writings of David Friesenhausen, who enthusiastically accepted Copernicanism and wrote a poem on the solar system to be recited on *Shabbat*, the Jewish Sabbath. In chapter 10, we study the way in which Jews responded to the new experimental evidence that supported the Copernican model and detail the works of Hayyim Zelig Slonimski, a member of the *Haskalah* (the movement of the Jewish Enlightenment), who wrote a text on the 1835 reappearance of Halley's Comet. Chapter 11 discusses Reuven Landau, who was unmoved by the growing evidence supporting Copernicanism. Landau wrote several books on mathematics, astronomy, and Jewish law, and concluded that it would "be better for Copernicus and a thousand like him to be removed from the world, rather than one word of the Holy Torah be changed." In chapter 12, we analyze the continued responses of Jews to Copernicus at the start of the twentieth century, and the contrasting responses of secular western Jews and Jews living in Muslim countries. Even in the post-Apollo era, the geocentric theory still had its defenders, and we discuss these modern Jewish geocentrists and their use of Einstein's theory of relativity in detail, and close with a review of Copernicanism in the contemporary *Haredi* (ultra-Orthodox) world. In the final chapter, we comment on the future of the interface of science and religion, based on the lessons that our study has offered.

While I was researching this book, a textbook used at a local Jewish day school was brought to my attention.[36] This book describes the appropriate blessings (*brohot*) to be recited over foods, natural phenomena, and various life events, and is popular among children who enter "*brochos* bees"—the Orthodox Jewish equivalent of a spelling bee. In the section covering blessings of praise and thanks, the appropriate blessing to be made "when seeing a wise man (non-Jew) in the secular fields such as a scientist" is

listed.[37] Throughout the book are illustrations, and the one that is included for this blessing is a stamp with a picture of Copernicus.[38] There are hundreds of scientists who could have been chosen to illustrate this blessing, and yet the author chose to include perhaps the most controversial of them all. How Copernicus came to be pictured in this study guide is the story of how even the most challenging of scientific discoveries can be accommodated into religious beliefs. In an era of increased cultural divisions between secular and religious worldviews, it is a story that has much to teach both sides.

A Brief Note on Transliteration, Terminologies, and Historical Methods

I have generally followed academic conventions for the transliteration of Hebrew terms and book titles. No difference is made between the Hebrew letters *hey* (ה) and *het* (ח). There has been no attempt to indicate a difference between the Hebrew letters *aleph* and *ayin*, *kaf* and *kuf*, and no hyphens have been inserted to separate the definite article *ha* from the rest of the word. The Hebrew letter צ has generally been transliterated as *z*, unless a common usage of another spelling prevailed. In addition, I have followed the most commonly used forms for the names of certain historical figures, thus Moses Maimonides (and not Moshe), Jonathan (and not Yonason) Eybeschütz, and Baruch (not Barukh) Spinoza. Unless otherwise noted, all translations from the Hebrew are by the author. Every attempt has been made to translate the text literally, but all translation is of course interpretation. Even translating the three simple but crucially important words from Ecclesiastes (1:4) raises a challenge. "*Veha'artz le'olam omadet*" can be translated in a number of ways, each of which subtly alters its meaning: "the Earth remains for ever"; "the Earth stands for ever"; "the Earth abides for ever." Then there is another translation, the one that a number of Jews (together with the Catholic Church) favored: "the Earth stands still for ever." Whenever possible, I have indicated where words have been inserted in the translation to explain the meaning of the original Hebrew.

Throughout the text, we have occasion to refer to certain personalities as *scientists* and some of their actions as doing *science*. The term *science*, however, was not yet used at the time that many of these people described as scientists actually lived. The word *scientist* was not coined in the English language until the nineteenth century and not regularly used until the twentieth.[39] In the seventeenth century, the term describing one whom we would today think of as a scientist was *natural philosopher* or *naturalist,* and what today we describe as science would then have been called *natural philosophy*.

While I recognize this, in order to avoid unnecessarily long terminology, I use the modern term *scientist* to describe those people who aimed to learn more about the natural world by observation, experiment, and exploration. This also avoids what one historian has called "linguistic chauvinism," for the Italian term *scienziato* (scientist) appeared in Galileo's writings, indicating that its use in languages other than English has a longer history.[40]

Finally, throughout the text, reference is made to the "Copernican theory," the "Copernican model," and the "heliocentric model." These are generally used interchangeably, unless addressing a specific historical phase, which will be readily apparent from the context. The Copernican model was modified by Kepler, who demonstrated that the planets do not orbit the Sun in perfect circles, but instead follow elliptical paths. Thus, the model in which the planets orbit the Sun would best be described as the "Copernican model as modified by Kepler," but this is an unwieldy and unnecessarily lengthy phrase. I have therefore chosen to refer to the model in which the Earth orbits the Sun simply as the "Copernican model."

A general question that arises as we strive to understand the history of an idea is the extent to which certain published books were influential. This study, after all, is an attempt to understand the reception of the Copernican model in the Jewish community as a whole, not just for those who studied it in depth or published works about it. Alas, there are no recorded oral histories or similar records that allow us direct insight into this, and we must rely instead solely on an analysis of published books and unpublished manuscripts. The danger in this is that peer review as we know it today was entirely lacking, and authors paid for their books to be published by raising funds privately or by seeking subscriptions in advance of publication.[41] The danger for the historian is that analyzing these works might be the modern equivalent of evaluating the influence of an idea based on the kind of books published by a vanity press. It would of course allow for some tentative conclusions to be made, but they would be limited in scope.

Fortunately, there are several reasons why we can indeed proceed with our analysis. In the first instance, many authors would write a précis that would be shown to prospective subscribers. On the basis of this (and of course the author's reputation and powers of persuasion), a decision would be made to support the author. As a result, the number of subscribers (whose names some authors published on the opening pages of their works) is a reasonable indication of the level of public interest in a specific book, in addition to the simple fact that the work was being published at all. Furthermore, publishing houses were, like any business, interested in ensuring a profit, and as a result were unlikely to publish books that would not sell. Finally, we can gauge the influence of a specific book by the number of separate editions in which it was

published, together with the number of years in which the work was in print. These factors allow us to make some reasonable conclusions about the influence of a particular work and the ideas that it contained. With these preliminary remarks completed, we now turn to study the life and work of the man who started it all: Nicolaus Copernicus.