

JEREMY BROWN

Rabbi Reuven Landau and the Jewish Reaction to Copernican Thought in Nineteenth Century Europe

In the opening years of this century, Rabbi Shlomo Benizri, once Israel's Minister of Labor and Social Affairs, published a comprehensive textbook on the Jewish calendar titled *Ha-shamayim Mesapperim* (*The Heavens Proclaim*).¹ Most of R. Benizri's work covers the complex mathematical and astronomical foundations which determine the structure of the lunar based Jewish calendar, and the last part of the book describes the nature of the solar system. In this last section, R. Benizri concludes that despite nearly five hundred years of scientific and astronomical evidence to the contrary, it is the sun that revolves around the earth, not vice-versa. Although R. Benizri was educated in traditional Orthodox yeshivot and never attended university, his book made use of many modern scientific instruments and discoveries. It reproduced high resolution telescopic images of the surface of the planets (including those sent from the famous Viking 1 Project) and described the composition of the atmosphere and surface of the planets using data from NASA's solar explorations. And yet, after a lengthy analysis, R. Benizri stated that the earth does not orbit the sun, because, in his account, the Bible, the rabbis of the Talmud and their medieval commentators had all concluded that the earth lay at the center of the universe.

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If R. 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 . . . kabala." The purpose of this bizarre allegation was to demonstrate that since evolutionary theory, considered by all to be a scientific theory, was in point of fact a religious concept (or, as the Representative from Georgia put it, a creation scenario of the "Pharisee Religion"), the Constitution should prohibit it from being taught in publicly funded schools. Thus, 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 advocating for the fixed earth position. His memo was circulated with a letter of support from the second most senior Republican politician in the House, Representative Warren Chisum, who served as Chair of the 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, R. Benizri and Bridges, would no doubt have been united in their fight against the common enemy, the Copernican credo.³ The positions that R. Benizri and Representative Bridges—one an ultra-Orthodox member of the Israeli Parliament and the other a fundamentalist Christian member of the Georgia State Legislature—share with regard to Copernican thought are shared by very few others from their respective faith traditions. Yet both are contributing 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.

In the history of the interface of science and religion, the battle over the Copernican model of the solar system surely ranks as one of the most important episodes. While some of the Jewish thinkers who took part in the debate such as David Ganz, Tuviah Cohen and Pinhas Horowitz are

well known, one of the participants, R. Reuven Landau, remains a somewhat obscure figure. His writings, although not widely studied today, are important because they articulated one of the only spiritual defenses of geocentrism. Unlike the anti-Copernicans who had preceded him, R. Landau's primary concern was not that a heliocentric system would contradict the words of the Bible—although he claimed this too. Rather, his was an assessment of the spiritual implications of a universe in which the earth is not the center. R. Landau outlined in a way that no one had yet done the spiritual dangers of accepting Copernican theory, while also raising some scientific doubts about both the Copernican model and the scientific method. Understanding his approach will help set the contemporary arguments over the heliocentric model of the solar system in a historical context.⁴

R. Landau's Life and Interests

Although he wrote four books, little is known of R. Landau's life.⁵ He was born in the early 1800s, but the exact date is not certain, and there are conflicting accounts of the date of his death in 1883.⁶ He married—apparently at a young age as was the custom—Bruna, the only daughter of Rabbi Yosef Landau of Lafli in Romania, and probably adopted the name of his wife's family as his own. This town, known as Yas in Yiddish, was a center of Jewish life, and the capital city of Moldavia; its Chief Rabbi was an influential and important figure. Yosef Landau was appointed Chief Rabbi of the town in 1834, where he stayed until his death twenty years later. While there, Yosef Landau published a collection of responsa called *Birkat Yosef*, and gained a reputation as a first-rate scholar. Reuven Landau was educated in his father-in-law's house and was profoundly influenced by him. This is clear from the title pages of his books, on which Reuven does not mention his own father's name, but refers to himself as “the son-in-law of the Rabbi, true Gaon, the famous Ḥasid, our teacher Yosef.” Indeed his identification with his family-by-marriage reached a strange end; on the title page of his last book, published posthumously in 1890, Reuven is no longer identified as the son-in-law of Yosef, but rather as his son.⁷ It was probably through the interventions of his famous father-in-law that that Reuven Landau was appointed to the position of the Chief of the Rabbinical Court of Padutark, where he served for some forty years until his death in 1883.⁸

R. Landau wrote several works which were published late in his life;

Middah Berurah (1882) on trigonometry; *Degel Maḥaneh Reuven* (1884) on Aggadah, and *Shem Olam* (published posthumously in 1890) on the correct spelling of Hebrew names. But the book which will concern us is *Mahalakh ha-Kokhavim* (*The Path of the Stars*), which was published in 1882 in Chernovstky and never reprinted. It appeared in the last year of R. Landau's life, and represented the culmination of his life-long fascination with astronomy and mathematics.⁹

As a young man R. Landau realized that that to acquire an expert understanding in astronomy and the formulation of the Jewish calendar would require a strong mathematical background. In order to attain this, he dedicated part of each day to the study of mathematics and trigonometry.¹⁰ The texts that he used for his course of self-study that culminated in *Middah Berurah* are not known. R. Landau articulated several reasons why the study of mathematics and astronomy was so important:

. . . aside from the study of the Torah, among the other . . . branches of wisdom, the study of astronomy is the most honorable and important of all. There are five reasons for this: 1) The sanctification of the new month and the calculation of the dates of all the festivals in the Torah are both dependent on it, and this was the first command that the Children of Israel were given. . . . 2) Through the command to calculate and declare a new month God showed his great kindness and love for us. By giving us the power to [calculate and] declare a new month, or to intercalate the year [God handed over great power to the Sages]. . . . 3) The other nations of the world recognize and thank Israel for their skill in this science, for [astronomy] is extremely important to all of the peoples of the world, and astronomy was first learned from us, as is stated in many books (and only later, due to our exile and dispersion, was this science lost to us and learned by the Gentile sages) . . . the astronomer Ptolemy praised us and those of us who developed the nineteen year cycle,¹¹ and Ptolemy himself wrote that this knowledge certainly came through prophetic insight. . . . 4) This science is more worthy than the other sciences because . . . its subject and focus are the heavens and the stars which . . . are eternal. This is unlike the natural sciences which investigate substances made of the four basic elements, which do not last. 5) When a person studies [astronomy] in detail, and understands the sizes of the sun and moon and all of the planets, and the huge numbers of stars, then he will see the wonders of God . . . which are awesome, and he will recognize the greatness of God and the smallness of humanity. In this way a person will be inspired to forever serve God. . . .¹²

Mahalakh ha-Kohavim

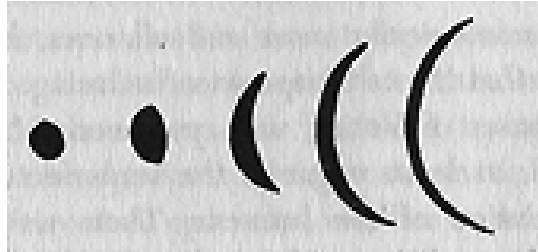
In *Mahalakh ha-Kohavim*, R. Landau had two objectives. The first was to explain the fundamentals of astronomy and trigonometry, and the second was to “explain well all of the theories of the later astronomers of our time, the basis of the foundations on which they based these theories, as well as other details of these theories.”¹³ R. Landau began his study with an explanation of gravitational attraction, without which the heliocentric system could not be understood. But R. Landau was careful to point out the divine in this natural force; he described gravity as the force “. . . which God, blessed be His name, has placed in the center of objects.”¹⁴ This weaving of divine design and natural law is a theme that runs through R. Landau’s work, and it is interesting to note that Copernicus himself described gravity together with what he perceived to be its divine origins, when he wrote that “. . . gravity is nothing but a certain natural tendency to draw together, which is implanted in parts by the divine providence of the Maker of all things.”¹⁵ Although it is unlikely that R. Landau had read Copernicus’ work, he certainly was familiar with writings of Copernicus and the history of his discovery, and explained to his readers how the heliocentric theory emerged.

This new theory did not suddenly develop. . . . At the start of the sixteenth century the astronomer Copernicus contradicted the astronomer Ptolemy who lived some fourteen centuries prior. He rejected the notion that the sun and all the heavenly bodies orbit the earth, and also rejected the existence of the solid spheres and their movement, which Ptolemy had established in his theory. He invented a completely new theory, in which the sun lies unmoving at the center of the constellations, and all the planets, including the earth, move around it through space. [Each planet] has two movements; one of which is the yearly orbit, and the other is a daily orbit around its own axis, causing the continual change from day to night. . . . Copernicus was certain that the orbits of the earth and the other planets around the sun were perfect circles, one with another . . . just as Ptolemy had proposed. However, at the start of the seventeenth century, another astronomer, Kepler, invented another system, and used new proofs to show that the earth and the planets orbited the sun through space in an elliptical manner. . . .¹⁶

R. Landau reviewed Copernican theory at some length, and summarized the three compelling pieces of evidence for the heliocentric theory, all of which he would later seek to refute.¹⁷ The first was the result of observations using the telescope, and in particular the phases of Venus, famously discovered by Galileo. By December of 1610, Galileo had noted that Venus seemed to change shape, just as the moon did,

sometimes appearing almost (but never quite) full, sometimes as a half-circle, and at other times sickle-shaped, as shown in Figure 1.

Figure 1. The phases of Venus as observed through a low power telescope.

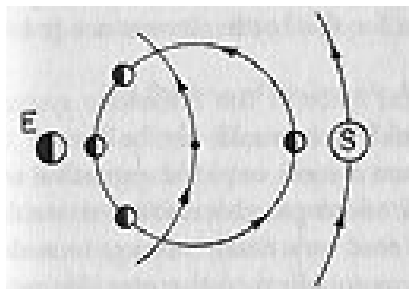


Notice how Venus wanes and simultaneously increases in size as its orbit brings it closer to the earth.

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It was not possible to explain these phases using the old Ptolemaic model, in which Venus should never be seen as other than a thin crescent of light, as is clear if we consider the Ptolemaic model in which Venus orbits the earth (see Figure 2). If the Copernican model were correct, the entire face of Venus would never be seen since this would only be observable at a point directly behind the sun. An almost circular face of Venus however, would be seen just before or just after Venus crossed the sun, and the size of the image of the planet would vary as its orbit brought it closer to or further away from the earth (see Figure 3).

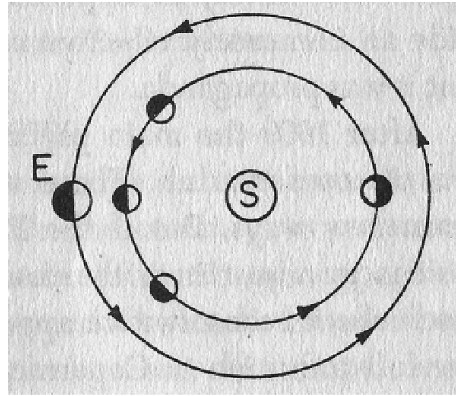
Figure 2. The phases of Venus in the Ptolemaic system.



Note that an observer on earth would never see more than a thin crescent of the lighted face of Venus.

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Figure 3. The phases of Venus in a Copernican system.



Note that the observer should see nearly the entire face of Venus illuminated just before or after Venus crosses behind the sun.

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All the observed phases of Venus were most easily explained as resulting from Venus orbiting the sun, and although this did not prove Copernicus correct, it was among the most powerful supporting evidence for the heliocentric theory.¹⁸ R. Landau demonstrated his familiarity with the evidence of the phases of Venus:

For it has been shown in our time and with our own eyes using good telescopes that Mercury¹⁹ and Venus, which orbit between the earth and the sun, each demonstrates a waxing and waning of its light depending on its position between the earth and the sun. This is like our own moon whose light waxes and wanes.²⁰

In addition, R. Landau described another discovery made by the telescope, namely that the planets revolve around their own axis, and that they appear to be orbited by their own newly visualized moons. These discoveries were another piece

. . . of evidence that the earth revolves around its own axis and orbits the sun each year. For why should the earth be different and unique compared to all the other planets which are several times larger than it? Why would [only the earth] remain at rest without any movement at all?²¹

The second kind of evidence for the heliocentric model that R. Landau considered depended not on observations but rather on the power of probabilities. He understood that part of the appeal of the heliocentric system was that it just seemed more probable.

Jupiter is 1,333 times larger than our earth. Saturn is 928 times larger than the earth. Uranus is 76 times larger than the earth, and the sun is 3,742 million times larger than the earth. If so, is it possible that our earth would remain stationary while the sun and the other large planets would serve us and revolve around the earth, only to illuminate it and to serve its needs?²²

Finally, R. Landau turned to the evidence from pendular motion, and the famous experiment by the French physicist Leon Foucault, which will be described in more detail later.

The latest astronomers make themselves seem great, and fill themselves with pride. They state that aside from these reasons [stated above], they also have another incontrovertible proof from the earth itself, that it orbits the sun; this is [the evidence] from their widely known pendulum.²³

Unfortunately R. Landau did not have the help of a good editor. He mentioned several objections to Copernicus in his work, but often did so in a rather piecemeal fashion, raising an objection in part and returning to it several pages later, often using the very same phraseology. In order to best understand R. Landau's challenges to Copernicanism, we will analyze his arguments thematically rather than in the order in which they appeared in his work.

R. Landau's Objections

1) FROM BIBLICAL TEXTS

R. Landau's first criticism of the heliocentric model was also the oldest and most frequently raised. It was of course, the text of the Hebrew Bible, and R. Landau felt it was all that was needed to in order to undermine the work of the new astronomers.

This system is absolutely false, do not believe it and do not listen to them in any way, for this is rejected by the Scriptures and by the holy prophets. For it states in Kohelet that "the sun rises and the sun comes" [Eccl. 1:5] And in the tenth chapter of the Book of Joshua it states ". . . the sun stood motionless in Giv'on" [Josh. 10:13] and in the thirty-eighth chapter of Isaiah it states ". . . the sun returned ten degrees, the number of degrees it had moved" [Isaiah 38:8]. And all of these verses must be interpreted according to their plain meaning, namely that the earth rests in its place, and that the sun, the moon, and all the other planets orbit it.²⁴

In this respect his approach was similar to that of the Catholic Church when it determined that biblical passages could only have a literal inter-

pretation. This was made clear in the infamous decree of the Congregation of the Index of the Church, which banned Copernicus' work:

It has come to the attention of this Sacred Congregation that the Pythagorean doctrine of the mobility of the earth and the immobility of the sun [which] is false and completely contrary to divine scriptures.²⁵

R. Landau's biblical objections were the same as those made initially by R. Yaakov Emden and quoted by Ḥatam Sofer.²⁶ But although R. Landau's arguments were not novel, the rhetorical force of his position was noteworthy. After quoting these objections from the text of the Bible, R. Landau wrote that it “. . . would be preferable to let the astronomer Copernicus and another thousand like him be removed from this world, rather than one letter of the holy Torah—of the Prophets and the Holy Writings—be annulled.”²⁷ This statement sounds extreme to our modern sensibilities, and it is a condemnation of Copernicus that had not been made in over three hundred years of Jewish writings against the astronomer. However, its severity needs to be tempered by some background. The phraseology which R. Landau chose—to “let Copernicus and another thousand like him be removed from the world”—was not original. The expression first appeared in the Jerusalem Talmud in a story in which King Solomon read some aspects of Torah law as not being applicable to himself. After a letter of the Torah appealed to God to stop Solomon, God's reply was unambiguous: “Let Solomon and another thousand like him be erased, before I erase part of you.”²⁸ This phrase made its way into rabbinic response literature in the fourteenth century, when R. Shlomo ben Aderet (Rashba) used it to silence what he felt was scientifically implausible testimony. “Let the witness and a thousand like him be erased, and let not one jot be erased of that which the Sages of Israel, who are holy and are prophets and the descendants of prophets. . . .”²⁹ While not original, R. Landau's phrase is nevertheless notable for it allows no subtlety, no room for maneuvering. Copernicus is wrong, and his worldview can never be aligned with that of the Torah.

2) SCIENTIFIC OBJECTIONS

a) The Impossibility of Rapid Motion

R. Landau was not content to battle Copernican thought simply by using literal readings of the Bible. He advanced three scientific objections to refute the heliocentric model, which he outlined in the fifth chapter of the second part of *Mahalakh ha-Kohavim*. His first objection was that there was no sensation of motion felt by those on the earth. If

the earth turned on its own axis and orbited the sun at the required rate of high speed, he questioned how it would be possible for life to exist and for objects not to be thrown from the earth's surface.

How is it possible that the earth should revolve on its axis each day at the amazing speed of three and a third *parsa'ot* each minute, and in addition to this it has a motion in an ellipse about the sun every year . . . and yet nevertheless the earth is able to keep on its surface bodies both animate and inanimate, along with all of mankind. Moreover all of these bodies are able to walk upright and not fall over; this is indeed very strange and difficult to comprehend.³⁰

b) Parallax

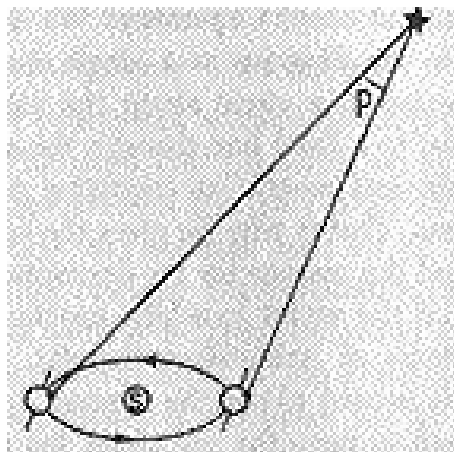
R. Landau's second objection was the lack of stellar parallax. If the earth revolved around the sun, then its movement should cause a close star to appear to move against the heavenly background. Parallax is an easy concept to demonstrate; simply hold out an arm and raise one finger. Close one eye and note the apparent position of your finger against the background, and then open that eye and close the other; the finger will appear to jump positions. The apparent movement of the finger is clearly due to a change in the position of the observer—in his case, the different position of the eyes. If the earth moves, this same phenomenon should be observed with the stars. As shown in Figure 4, the star's apparent position on the stellar sphere when observed from the same place on earth would appear to move by an angle p over a six month period. R. Landau believed that the fact that this movement had not been detected proved that the earth was not moving. He wrote:

We see that when two stars are viewed against two fixed objects on earth, they remain fixed against these objects and do not move at all. Now according to Copernicus, the earth moves about its axis and around the sun, along an elliptical path. This elliptical orbit is 41 million *parsa'ot* each year. . . . How then, can it be that the earth moves along such a vast path, and yet the two stars do not move from their fixed points [against the sky's background]?³¹

The lack of a measured stellar parallax was indeed a serious challenge to the heliocentric model. It had already been noted by Copernicus himself, who explained (correctly as it turned out) that the distances from the earth to the stars are simply too vast for any change in the earth's position to cause the effect of parallax, since the angle p would be too small to measure.³² But R. Landau's science was not current, for in 1838—fifty years before R. Landau's book was published—the German astronomer Friedrich Bessel calculated stellar distances based on accu-

rate measurements of stellar parallax, and was awarded the Gold Medal of the Royal Astronomical Society for his work.³³ Whether or not R. Landau knew of Bessel's work and chose to ignore it, or whether he raised the issue of parallax because he believed it to be a solid criticism of the Copernican model, cannot be determined. We should note, however, that while much of R. Landau's astronomy was based on earlier Hebrew works, he was certainly aware of more contemporary scientific discoveries, such as Foucault's pendulum. It is therefore not unlikely that Bessel's work could indeed have come to R. Landau's attention, only to be ignored.

Figure 4. Annual parallax of a star



The line between an observer on earth and a fixed star does not stay quite parallel to itself as the earth moves in its orbit. The star's apparent position on the stellar sphere should move by an angle p after six months.

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c) Common Motion

The third scientific objection raised by R. Landau was based on an understanding—and a misunderstanding—of what had come to be called common motion. This argument suggested that if the earth were really moving, then a stone thrown upwards should land some considerable horizontal distance away from its launching point, since the earth rotates from west to east during the period in which the stone was airborne. Empirical testing revealed that the stone actually lands back at its launching point, and so the earth clearly does not move. R. Landau wrote that if Copernicus was correct, and the earth orbits the sun from west to east, then

... it would be expected that a stone which fell from the top of a tall tower

on its western side would not land exactly at the base of the tower but would come to rest slightly to its west. The explanation for this is that during the time that the stone was falling, the earth together with the tower were turning towards the east. . . . Yet we see with our eyes that this is not the case; rather the stone falls and comes to rest precisely at the foot of the tower. It is not possible to refute this objection by saying that the atmosphere above the earth that turns with the earth at the same speed pushes and forces the stone towards the tower. Such a thought is not logical, for there is certainly not enough force in the atmosphere to move a physical object. Only the wind which blows has the power to do this, but not the atmosphere which is stable and stationary. . . . Furthermore, has not the astronomer Tycho Brahe in his disputes with Copernicus performed experiments involving a stone falling from a tall tower and convincingly shown for all to see that the earth remains at rest in its place, and does not move at all? Copernicus has not been able to respond to this [defeat] in any way. . . .³⁴

Once again, R. Landau's attack on Copernicanism was a critique of scientific knowledge combined with an ignorance of the sources which he quotes. R. Landau quoted Tycho Brahe's arguments and his forceful statements that "Copernicus could not answer them at all," and indeed Tycho had stated these and other arguments in letters written between 1586 and 1590.³⁵ But in point of fact these arguments had been raised and refuted by Copernicus,³⁶ Galileo,³⁷ and many others,³⁸ using various explanations that involved the notion of common motion. For example, Galileo wrote that "a stone projected from the top of a mast always fell to the foot of the mast, never into the sea, whether the ship was at rest or moving quickly,"³⁹ although this experiment was hard to perform accurately. It was the common motion of the ship and the stone that was the cause of this result. R. Landau chose not to mention these—and other—explanations, either because he was not familiar with them, or, as is more likely, they would serve to undermine his criticism of Copernican thought.

d) Tycho Brahe and Scientific Skepticism

After R. Landau raised these three objections, he presented an alternative explanation, which had come to be known as the Tychonic model. In this model, all the planets—except the earth—did indeed orbit the sun, but the sun itself revolved around the stationary earth, taking the other planets with it on its yearly cycle. At first, R. Landau did not identify the Danish astronomer Tycho Brahe by name as the progenitor of this system:

It has already been noted in astronomy books that even during the lifetime of Copernicus, when his theory was first publicized, there was a certain

famous astronomer who taught Copernicus philosophy and who completely rejected the Copernican model of the earth's movement. He did this with the proofs that we have just noted, and also discovered a new and different model. This model contains parts of the model of Copernicus, while the foundations are those of Ptolemy. For this astronomer stated that all the planets orbit in space around the sun due to the gravitational force of the sun, just as stated by Copernicus. However, he left the immobile earth at the center of the zodiac, in keeping with the ancient astronomers, and stated that the sun and all the planets that orbit the sun also in fact orbit the earth. . . .⁴⁰

However, R. Landau was careful to point out that this alternative model need not be correct either. Rather, he noted that scientific theories are constantly undergoing changes, with some new theories becoming widely accepted, while others—once themselves universally acknowledged as true—are discarded.

This astronomer was unable to have his theory concerning these strange movements of the sun and the planets accepted in his day...As a result it became forgotten. But perhaps there will be a time in which a later generation happily chooses to accept this theory, and decides to reject that of Copernicus. Do not think that just because the Copernican theory is now widely accepted that this could never happen. For as you know, Ptolemy's ancient model was widely accepted for over fourteen hundred years. No one ever questioned it, and all accepted it. Then Copernicus arrived and contradicted Ptolemy's model, creating a new and different model. Consequently, it is not unlikely that at a future time a new astronomer will disprove Copernican thought, reject the earth's movement, and return to the currently rejected models. . . .⁴¹

This objection was quite different from those that R. Landau had previously raised, and it addressed the very nature of the scientific process. For R. Landau, accepted scientific explanations change over time. History had demonstrated that a widely accepted astronomical model was eventually overthrown; this same lesson should apply to any contemporary theory.

Even the model of Tycho Brahe, which is better and more accurate than Copernicus's should only be accepted provisionally. That is to say, it may be correct, but it is not absolutely certain that this is so. . . . And should another wise and more famous astronomer appear and suggest a more perfect and complete model, which contains no inconsistencies and appears without weaknesses, even in this case, it should only be accepted in a conditional way. For the omnipotent God, capable of creation *ex nihilo*, could certainly order the planets in any way . . . and in reality neither astronomer may be correct.⁴²

Although Copernican thought seemed to be both widely accepted within the scientific community and contrary to Jewish belief, R. Landau's conclusion was that there was no reason for concern. All scientific theories are in a state of constant flux. By taking the long historical view, Jewish belief will ultimately be vindicated.

While R. Landau remained skeptical of science, it is striking to note the similarity to his thinking to that of another—although this time far more famous—skeptic about science, Michel de Montaigne. Montaigne was born to a wealthy family in Bordeaux in 1533; his mother was of Spanish Jewish descent. Of the hundreds of pages of essays which he left, his longest and probably most famous was called *Apology for Raymond Sebond*. In it, Montaigne described the limits of human reason and the grounds for extreme skepticism. What is of importance for our investigation is Montaigne's analysis of the Copernican revolution. Rather than increasing our knowledge of the way the universe functioned, Montaigne concluded that it actually left us even more uncertain of reality.

The sky and the stars have been moving for three thousand years; everybody had so believed, until it occurred to Cleanthes of Samos, or (according to Theophrastus) to Nicetas of Syracuse, to maintain that it was the earth that moved, through the oblique circle of the zodiac, turning about its axis; and in our day Copernicus has grounded this doctrine so well that he uses it very systematically for all astronomical deductions. What are we to get out of that, unless that we should not bother which of the two is so? And who knows whether a third opinion, a thousand years from now, will not overthrow the preceding two? . . . Thus when a new doctrine is offered to us, we have great occasion to distrust it, and to consider that before it was produced its opposite was in vogue; and as it was overthrown by this one, there may arise a third invention that will likewise smash the second. Before the principles that Aristotle introduced were in credit, other principles satisfied human reason, as his satisfy at this moment. What letters-patent have these, what special privilege, that the course of our belief stops at them, and that to them belongs the possession of our belief for all time to come? They are no more exempt from being thrown out than were their predecessors.⁴³

Although it would be another fifty years or so until the sociology of scientific explanation was widely studied, R. Landau's insistence on not overlooking rejected explanations or models was almost certainly based on a similar approach found in the Talmud, in which two seemingly conflicting opinions are both viewed as capable of being correct. This idea is conveyed by the talmudic dictum that "these as well as those are the words of the living God" (*Eruvin* 13b). In this approach, minority

opinions are recorded for later scholars to consider because circumstances may change and the reasoning that was once rejected may again become acceptable. Here is how Rashi, the eleventh century commentator on the Talmud, understood this notion.

When two Amor'aim disagree with each other about the law, there is no untruth here. Each is able to justify his opinion; one brings a reason to permit, and the other brings a reason to forbid. One compares the case to one paradigm, and the other to something else. Yet it is possible to say "these all well as those are the words of the living God," for sometimes one reason will be valid, and at other times another reason will be valid. For reasons may change depending on the smallest of changes in reality.⁴⁴

R. Landau seems to have adopted a similar approach to the question of scientific veracity, and he considered it quite possible for hypotheses which had been rejected in the past to be rehabilitated in the future. However, in maintaining this position, R. Landau ignored the critical point that unlike ethical or religious considerations, scientific theories had to answer to the facts of observation and experiment. This distinction between different legal theories based on rhetoric, and scientific theories based on observation or experiment, was not made by R. Landau. Rather, in R. Landau's construct, all theories have the potential to be accepted and rejected at some point, depending on the circumstances of the times.

e) Foucault's Pendulum

R. Landau returned to the theme of scientific skepticism in his discussion of Foucault's pendulum.

Although the astronomers of our time pride themselves, that they have found a compelling demonstration that the earth moves by using the pendulum, this too you should dismiss. For it has happened many times that an earlier researcher proved a point beyond a doubt using an unequivocal demonstration, and yet a later researcher came and disproved that which was established earlier, including the [previously] convincing demonstrations, and demonstrated a new explanation for the findings.⁴⁵

We must pause briefly to consider this famous scientific experiment that occurred prior to the publications of R. Landau's work. Towards the middle of the nineteenth century, several attempts were made to verify experimentally the Copernican model. Of these, perhaps the best known was that of Foucault, who demonstrated that the plane of a swinging pendulum appeared to move relative to the earth underneath. Since there was nothing causing the pendulum to change its direction, Foucault concluded that it was the surface of the earth moving under-

neath the pendulum which was responsible.⁴⁶ This experiment, originally performed in Foucault's basement, was announced in Paris on February 3, 1851. Foucault staged a spectacular demonstration at the Pantheon and the experiment was soon repeated by other physicists. For example, another display of Foucault's pendulum in the same year took place in Rome; this time it was demonstrated in the Church of Saint Ignacius in the Vatican itself, the very epicenter of the Catholic anti-Copernican movement. In 1879 in Groningen, a city in the north of the Netherlands, H. Kamerlingh Onnes (who would go on to win a Nobel prize in 1913 for his work on the properties of matter at low temperatures) presented a classic paper on pendular motion and the movement of the earth.⁴⁷ Foucault's pendulum was a serious experimental challenge for geocentricism, for it provided the first experimental evidence that the earth moved on its axis (although it did not prove that the earth moved around the sun).⁴⁸

Foucault's experiment received wide publicity, and news of it made its way to the rabbinical court of R. Reuven Landau in Padutark. R. Landau's discussion of Foucault's pendulum appears to be the only discussion of its kind in rabbinic literature. R. Landau did not provide an alternative explanation for the movement of the pendulum, which would have been difficult to do, but which was called for if indeed this most visually impressive of experiments was to be ignored. Instead he chose to question notions of scientific knowledge, and of the manner in which scientific explanations change over time. But one can almost sense R. Landau's own dissatisfaction with his criticisms of the pendulum experiment. After a few lines he turned to what appeared to him to be a more substantial line of questioning. This was not in the form of questions from scientific experiments themselves, nor proof texts from the Bible. It was instead a set of profound theological objections to the Copernican model which questioned the relationship of humanity to the universe itself.

3) SPIRITUAL OBJECTIONS

R. Landau's thesis was that the universe could not do otherwise than literally revolve around a stationary earth, because humanity lay at the spiritual center of the universe.

 Saturn is 928 times larger than earth, and Uranus is 76 times the size of earth. How much more so the size of the sun itself compared to the size of the earth . . . is it possible that these planets should serve the earth which would remain unmoved and at rest in its place, and they would serve the earth and orbit it in order to illuminate it and give it all it need-

ed? Would they themselves have no other purpose? Now anyone who can understand knows that it is only as a result of the opinion that man is insignificant and of less value than the stars and planets that they have come to believe this and asked these questions . . . but they do not know or understand the value of the souls of mankind that are pure and righteous, who live on the earth. For the source [of the true way] of thinking is from a more elevated and very much higher world than the world of the angels, and how much more so than the world of the planets. When man redeems himself and purifies his body and his material self by constantly serving God with love and awe, and when his soul and spirit and thought cleaves to God and when he carries out his Torah and *mizvot*, then he brings life and sustenance from God to the entire world. This is what is explained in the Holy Zohar . . . and therefore this [geocentric view] is not surprising at all. For it is certainly appropriate and very correct that the stars and planets should orbit the earth for us, for our needs, and to light our way and serve all our needs. For although they are much larger than us in size, nevertheless the value of our souls is much greater than them. They were created only for our purpose, as the verse states . . . and this is why Joshua had the strength to command the sun saying “Sun, be still in Giv’on” [Josh. 10:12] and the sun had to obey. . . . All the stars and planets were created for our purpose, for our use, as the verse states “He placed them in the heavens to shine down on the earth” [Gen. 1:15]. Therefore they are required to obey and follow the prophets and those who are the completely righteous, and must do their bidding.⁴⁹

In other words, humanity occupies a special position in the universe, a location which is not geographically but rather spiritually important. Through the worship of God (a behavior available to all of humanity), and keeping of the laws of His Torah (a virtue available only to Jews), a person elevates his physical body into a spiritual being. Since this is the very goal of God’s plan for universe, it is a natural consequence that the universe should serve humanity. Although such service could, of course, be provided in a Copernican model, the old order, that in which the earth is at the very physical center of the universe, serves to emphasize this special relationship. For R. Landau, the structure of the physical universe reflected the spiritual hierarchy designed by God. As a consequence, R. Landau’s model of the natural order included the ability of the Sages to actually change the natural world through the suspension of the laws of nature. He outlined this belief in the introduction to his book on trigonometry, where he explained that study of the sciences still required that the scientist be subject to the very laws of nature under study.

Aristotle himself, who was as famous as a natural scientist and in other branches of inquiry, was nevertheless unable to change the laws of nature

in any way. (For example, he could not produce rain when it was needed, and so on.) He was completely subjugated by and beholden to the laws of nature. This is quite unlike the Holy Torah . . . which induces a level of holiness in the soul of the man who studies it. . . . Therefore, the righteous who study the Torah for its own sake . . . are not enslaved to the laws of nature. On the contrary, Nature itself is subjugated to them and they have the power to change the laws of nature as the need arises.⁵⁰

This belief was repeated in the introduction to *Mahalakh ha-Kohavim*,⁵¹ where he quoted the talmudic belief that when the Beit Din changed a ruling regarding the intercalation of the year, nature itself changed to conform to the new calculation.⁵² R. Reuven Landau's fight against Copernican astronomy was about more than a belief in the literal meaning of the Bible, or a question of the scientific method. It was a concern about the spiritual place of humanity in a material universe. R. Landau understood the threat that the new astronomy brought to fundamental questions of religious thinking, and he articulated these threats in a more clear and direct way than his predecessors. If the earth was not at the literal center of God's creation, then humanity may also not occupy that place. Since this consequence was unthinkable, any model which moved the earth from its central position must be rejected. R. Landau's physical geocentrism was a result of his spiritual anthropocentrism.

These astronomers are mistaken, for the truth is that although the planets are much larger than our earth in terms of their size; nevertheless we, humanity that lives on the earth, outsize them in terms of the value of our souls. Our souls are from the highest of worlds. Through our worship of God with love and awe, and through the keeping of his Torah and mizvot with our souls cleaving to the Holy One, we make ourselves unique and more important than all the other planets, and bring God's blessing and sustenance to all of the universe.⁵³

Although as we shall see below, R. Landau clearly borrowed heavily from Horowitz's *Sefer ha-Berit*, his emphasis on the spiritual challenges of Copernican thought was novel. Indeed, in *Sefer ha-Berit* Horowitz wrote in no uncertain terms that acceptance of the Copernican theory was perfectly within the bounds of normative Jewish thought.

Any person of Jewish faith who believes in this theory should not be considered to be weak in his belief in the written Torah or the Oral Law, and certainly such a person should never be branded or suspected of heresy. Indeed he could be considered a *zaddik* among Israel, so long as his other beliefs and practices follow both the written Torah and the Oral Law, and he fears God.⁵⁴

While Horowitz concluded that Tycho's model was, in the end, the one that seemed to him most logical, he did not reject the Copernican model on spiritual grounds, but rather on physical ones. Horowitz was convinced that nature would not use two forces to cause an object to remain in place when one would do. This mistaken approach led him to conclude that since objects would remain in place on the earth due to gravity, there could be no additional force acting on any objects. This would lead Horowitz to conclude that centrifugal forces, (or as he described them "rotational forces") would not be necessary, and by conclusion, the earth is at rest.

For we know that God lifts up those who have fallen, and through gravity everything is attracted towards the earth's surface. As a result, all humanity and all living things, and indeed all objects on the earth do not fall off from its surface—the earth does not spew out its inhabitants. I must conclude from this that the earth remains stationary in one spot, for if God wished to create an earth which moved, objects would not fall from it as a result of its orbital movement. Why then, would there be the unnecessary force of gravity if the earth were moving?⁵⁵

There was also experimental evidence that challenged the Copernican model, such as the question of why a stone dropped from a tall tower fell at the foot of the tower and not some distance from it, but it is important to note that Horowitz did not pursue the spiritual objections to the heliocentric model. Elsewhere in *Sefer ha-Berit*, Horowitz wrote of the central place that humanity occupied:

How can it be the case that large planets are not inhabited, yet the smaller earth is inhabited? I can answer this, for everything was created for the benefit of the earth, and for the glory of humanity on the earth, as it is written "[God made two great lights, the greater light to dominate the day,] and the lesser light to dominate the night, and the stars. And God set them in the expanse of the sky to shine upon the earth" [Gen 1:16-17]. This is the very way it is in reality; [the stars and planets] were only created for the perfection of humanity on this earth, even if we do not fully comprehend all the other reasons for their creation.⁵⁶

One can certainly detect the early articulation of a spiritual objection of Copernicanism, but it was R. Landau who developed this idea into a forceful argument against the heliocentric theory. The novelty of R. Landau's spiritual defense is further appreciated when we contrast it with the criticisms of Copernicus leveled by Tuviah Cohen, who essentially dismissed the theory without really attempting to refute it.⁵⁷ David Nieto rejected the Copernican model because it contradicted those bib-

lical verses which described the sun as moving, even though the model was otherwise very compelling.⁵⁸ R. Landau was certainly aware of these prior arguments, and included them in his own list of objections. However, his emphasis on the spiritual implications of re-placing the earth from the center of the universe was truly innovative.

4) SEFER HA-BERIT

When we consider the possible sources for R. Landau's anthropocentric structure of the universe, it is certain that R. Landau had relied on *Sefer ha-Berit*. This work, part encyclopedia and part Kabbalistic treatise, was first published anonymously in 1797, but in a second expanded edition, published in 1818, Horowitz identified himself as the author. Horowitz's book, which has been called the "first Jewish encyclopedia," contained several chapters on astronomy, including consideration of the Copernican system.⁵⁹ As we noted, when faced with a need to explain why other large planets would remain uninhabited, and yet there was life on the smaller planet earth, Horowitz explained that the entire universe was created for man. There can be no doubt that R. Landau was familiar with this notion from the *Sefer ha-Berit*, for there are passages from *Sefer ha-Berit* that appear virtually word for word in *Mahalakh ha-Kohavim*, although they are not acknowledged to be such. Here is how R. Landau described the objection from the falling stone, in which words and phrases identical to those in the *Sefer ha-Berit* are in bold:

אם כן כדברי קופרניקוס שהארץ סובבת במהירות סביב השמש ממערב אל מזרח
 היה מן הראוי שהאבן הנופל מראש עמוד הגבוה על הארץ מצד מערב לא יפול
 אצל רגלי העמוד ממש רק ינוח רחוק קצת מהעמוד לצד מערב מחמת כי בעת
 נפילת האבן התנועע וסיבבה הארץ עם העמוד בתוך כך לצד המזרח עד ג' פרסאות
 ושני שלישי פרסא והלא אנחנו רואים בעינינו שאינו כן רק שהאבן נופל ונח אצל
 רגלי העמוד ממש.⁶⁰

If it is as Copernicus has written, and the earth circles the sun at great speed from west to east, it would be the case that a stone which falls to the ground from the top of a high tower on its western side should not land exactly at the foot of the tower but rather should come to rest slightly to the west of the tower. For while the stone is in free-fall, the earth together with the tower have moved in orbit to the east, by three and two-thirds *parsa'ot*. Yet we see with our own eyes that this does not occur. Rather the stone falls and comes to rest precisely at the foot of the tower.

This should be compared to the nearly identical language Horowitz used in the *Sefer ha-Berit*:

אם הארץ מהיר בלכתו מאד מהמערב אל המזרח היה מן הראוי שהאבן הנופל מראש עמוד הגבוה מאד לצד מערבו שלא יפול אצל רגליו ממש רק ינוח ברחוק מה מרגליו לצד מערבו, להיות כי בעת אשר יפול התנועע הארץ עם העמוד לצד המזרח אחר מהרו בתנועתו בדקה אחד בשעה ג' פרסאות ושני שלישי פרסא וכל אשר יפול מננו אנו רואים שהוא נח אצל רגליו ממש.⁶¹

The astronomy of *Sefer ha-Berit* does indeed appear to be the foundation of R. Landau's own, although R. Landau failed to acknowledge Horowitz as his source.⁶² Although Horowitz was more sympathetic to Copernican thought than was R. Landau, he too ultimately chose to reject it in favor of the geocentric model.⁶³ Horowitz had also had a skeptical attitude towards scientific discoveries, which was later amplified by R. Landau. For example, Horowitz cautioned against rejecting Tycho's model, because

. . . who knows if at a later time or in one of the many future generations that will come after ours, his theory may be happily accepted. Then it may become permanently accepted, for this is the way among the Gentiles that some opinions have their time. At times they are rejected and at other times they are accepted. Even a theory which seems rejected from its very inception . . . eventually there may arise a person who adopts the theory and succeeds in spreading it across the entire world. Such a person would be very successful and become famous throughout the world, and every one would listen to him. . . .⁶⁴

5) R. LANDAU'S JEWISH SOURCES AND LIFE ON OTHER PLANETS

It is clear, then, that, although he failed to reveal it as a source, R. Landau based much of his anti-Copernicanism on *Sefer ha-Berit*. But there were several other Jewish texts that R. Landau quotes by name, although he does not quote Gentile texts. R. Landau cited Tuviah ben Moses Cohen (1658-1729), author of the textbook of sciences known as the *Ma'aseh Tuviah*, which should be no surprise since the book contains a forceful rejection of Copernican thought.⁶⁵ What is surprising, however, is that R. Landau did not quote those parts of the *Ma'aseh Tuviah* in which Copernican thought was rejected, but chose rather to mention those parts which supported R. Landau's rejection of the possibility of life on other planets.⁶⁶ R. Landau questioned the findings made using the telescope, which revealed not only the existence of the moons of Saturn and Jupiter, but also the existence of "hills and valleys" on the moon on other planets, which might suggest that life was to be found there. These features were also evidence that the planets were not perfect objects, as demanded by Ptolemaic astronomy. R. Landau could not provide a cogent explanation for these features, other than to question them and to note that areas of darkness had also been noted on the sun. Despite these

sunspots, it was clear, argued R. Landau, that life could not exist on the sun itself, and so other blemishes (which were features of the geography of the planets themselves) would not necessarily lead to the conclusion that the planet was earth-like and supported life. It was this conclusion which was supported by Cohen, who wrote that “according to our Torah it is impossible that another earth-like planet exists.”⁶⁷

However, R. Landau was aware that not all modern thinkers had rejected the possibility of life on other planets. David Nieto (1654-1728), who became the *hakham* of the Spanish and Portuguese Synagogue in London, had addressed this possibility in his book *Matteh Dan ve-Kuzari Sheni*.⁶⁸ Nieto had written that while there was no certain answer, there was no reason to reject the possibility of life on other planets based on the teachings of the Torah.⁶⁹ This approach was not acceptable to R. Landau, who wrote: “I am very suspicious of this, and it is certainly possible that a later astronomer added these words into [Nieto’s] book.”⁷⁰ In other words, R. Landau claimed that this paragraph had been forged and added without the knowledge of the author. Such a claim was not likely, for Nieto’s book was published in 1714, fourteen years before his death, in Nieto’s adopted home city of London. Nieto would certainly have overseen the publication, and the claim that entire paragraphs were added without the author’s knowledge was absurd, but not without precedent within Jewish intellectual history.⁷¹ Over the centuries, there were several rabbinic scholars who dismissed problematic texts with a claim that these texts had been forged, and could therefore be ignored. R. Landau’s claim was another in this line, and although unusual, should not be viewed as unique.

The final Jewish source that was cited by R. Landau was the work of Raphael Halevi of Hanover (1685-1779), a mathematician and astronomer who had studied philosophy with Leibniz. Halevi published two books on astronomy in 1756,⁷² and one of these, *Tekhumat ha-Shamayim*, focused on astronomy and an exposition of Maimonides’ *Hilkhot Kiddush ha-Hodesh*.⁷³ R. Landau analyzed the tables that appeared in *Tekhumat ha-Shamayim* at some length.⁷⁴ This fact would not be terribly important, were it not the case that at the end of *Tekhumat ha-Shamayim* Halevi described in brief but flowery language his own conversion to a belief in the Copernican model. There can be no doubt that R. Landau, who praised the astronomical learning of Halevi, would have read this; indeed the large diagrams of the Ptolemaic and Copernican models which appear in the book make this section almost impossible to miss. And yet R. Landau did not mention Halevi’s Copernican conversion.

***Mahalakh ha-Kohavim* in the Setting of Other Nineteenth Century Jewish Astronomical Works**

The contribution that R. Reuven Landau made to the nineteenth century Jewish debate over the model of the solar system is best understood in the context of other germane works that were published in that century. The Catholic Church had shown itself more open to scientific realities, and had quietly removed the works of Copernicus and Galileo from its Index in 1835.⁷⁵ Whether this was responsible for a greater tolerance towards Copernican thought or one of its effects, this increased religious openness to science slowly made its way into the Jewish community. This, together with the emergence of the Haskalah movement and the increased access to scientific knowledge that was afforded to some, resulted in a rapid growth in the number of Jewish works on astronomy that discussed Copernicus. If we confine our remarks to books on this topic published in the nineteenth century—of which there were at least fifteen—we will note that nearly all were pro-Copernican. For example, R. David Friesenhausen published *Mosedot Tevel* in Vienna in 1820, in which he described at length the Copernican system and praised its advantages.⁷⁶ As we noted above, a second expanded edition of the *Sefer ha-Berit* was published in Vilna in 1818, and although the author ultimately sided with the geocentric model, he emphasized that belief in the Copernican system was certainly possible for a Jew who believed in God's divinely revealed Torah. This book was possibly the most widely read book of its type in the nineteenth century, and was published in twenty separate editions across Europe between 1801 and 1897. In preparation for the appearance of Halley's Comet, Ḥayyim Zelig Slonimski published *Kokhava de-Shavit* in Vilna in 1835. This book described where and when the comet would be visible, but only after a detailed exposition of the Copernican model which should be accepted as true alongside the eternal truths of the Torah, ". . . for both are true and given by the true God."⁷⁷ Joseph Ginzburg's *Ittim la-Binah* published in Warsaw in 1898 also contained an introductory note explaining how it was possible to accept the new astronomy while remaining committed to traditional Jewish thought.⁷⁸ In the same year, Dov Ber Rukenstein published a two part work on astronomy in Lvov, titled *Mesolot ha-Me'orot*. The entire second part was an explanation of the Copernican model and Kepler's rules of planetary motion, "which are accepted by all the astronomers and scientists of our time."⁷⁹ R. Reuven Landau was almost the lone geocentrist among these authors of his generation.⁸⁰ Although

R. Landau was familiar with many of the arguments which had been used to undermine the Copernican model the importance of his contribution was an emphasis on the spiritual challenge that Copernican theory presented to theology.

Tycho Brahe—whose model R. Landau preferred over that of Copernicus—had a pair of mottos which he used to support his belief in astrology: *Despiciendo suspicio* (“By looking down I see upward”) and *Suspiciendo despicio* (“By looking up I see downward”). The first motto, *Despiciendo suspicio*, could also have been the guiding principle of R. Reuven Landau’s geocentrism. R. Landau placed the earth at the center of the universe because humanity was at the spiritual center of that same universe. His astronomy was guided as much by his anthropocentric outlook as it was by his interpretations of the Bible. The philosopher of science Thomas Kuhn wrote that scientific arguments “. . . are forceful arguments, quite sufficient to convince most people. But they are not the most forceful weapons in the anti-Copernican battery, and they are not the ones that generate the most heat. Those weapons were religious and, particularly, scriptural.”⁸¹ Reading *Mahalakh ha-Kohavim*, it is clear that R. Landau gave even greater weight to the spiritual than he did to scientific and scriptural concerns. His emphasis on the spiritual challenges of this most material of theories both predated and predicted what has become to be known as the Copernican Principle, which states simply “you are not special.”⁸² R. Landau’s astronomy may have been wrong, but his perception of the challenges that scientific advances bring to religion in general and traditional Jewish thinking in particular seem to have been most prescient.

Notes

I am grateful to Erica Brown, Sol Schimmel, David Shatz and the anonymous reviewers, whose thoughtful comments helped me to improve this paper.

1. Shlomo Benizri, *Ha-Shamayim Mesapperim* (Jerusalem, 2003).
2. Chisum later retracted his letter of support, stating that “through further review” he came to realize that the memo did not reflect his views “about such a complicated and deep subject.” (See http://www.sptimes.com/2007/02/25/News/Flat_earth_society_s_.shtml, accessed Feb 7, 2008 and *The New York Times*, February 17, 2007).
3. R. Benizri is a spiritual heir of the Pharisees so demeaned by Bridges, but in battles such as these, perhaps it really is the case that the enemy of my enemy is my friend.
4. On Jewish reactions to the Copernican Revolution, see André Neher, *Jewish Thought and the Scientific Revolution of the Sixteenth Century: David Gans (1541-1613) and His Times* (Oxford and New York 1986); David Berger, “Judaism and General Culture in Medieval and Early Modern Times,” in Gerald J. Blidstein, David Berger, Shnayer Z. Leiman, and Aharon Lichtenstein, *Judaism’s Encounter with Other Cultures: Rejection or Integration?* (Northvale, NJ 1997), 133-35; Hillel Levine, “Paradise Not Surrendered: Jewish Reactions to Copernicus and the Growth of Modern Science,” in *Epistemology, Methodology, and the Social Sciences*, ed. R. S. Cohen and Marx W. Wartofsky (Dordrecht, Holland and Boston, 1983), 203-25; Michael Panitz, “New Heavens and a New Earth: Seventeenth- to Nineteenth-Century Jewish Responses to the New Astronomy,” *Conservative Judaism* 40 (1988): 28-42; and David Ruderman, *Jewish Thought and Scientific Discovery in Early Modern Europe* (New Haven: Yale University Press, 1995), 266-68. R. Landau is not mentioned even in studies that cover our time period. Most recently, R. Chaim Rapoport published a review (in Hebrew) of rabbinic attitudes toward Copernican thought. See Chaim Rapoport, *Ve-ha-Areẓ le-Olam Omadet* (“But the World Endures Forever”): On the Relationship Between the Torah Sages and the Views of Copernicus (Heb.), *Or Yisrael* 14,3 (Nissan 5769=2009):207-18.
5. Duber (Bernhard) Wachstein, *Mafteah ha-Hespedim* (Wien, 1922), vol 4, p. 27; R. Meir Vunder, *Me’orei Galizyah*, vol. 3 (Jerusalem 1986), 639-40. Vunder wrote that R. Landau was educated by his father-in-law.
6. R. Landau may have been born in 1813. The recorded date of his death varies; Vunder (vol. 3, col. 640) records that it occurred on 29 Av, 5643 corresponding to September 1st, 1883. However, R. Landau’s brother-in-law, Mattityahu Landau, in a lengthy eulogy published in the preface to one of R. Landau’s own works stated that the death occurred on Wednesday, 29 Sivan (“the twenty-ninth day of the month in which our holy Torah was given”), corresponding to Wednesday, July 4th, 1883. Since Mattityahu was an eye-witness to the death, we should assume his dating is the more accurate of the two. Mattityahu’s funeral oration gives a dramatic insight into R. Landau’s life and leadership style, and is the only first-hand account of R. Landau’s personality. This description, part of the eulogy given by Mattityahu for his brother-in-law, is striking:

For forty years he was the Rav and religious leader here in Paduturk. All of the surrounding towns in the country asked that he be crowned their rabbi, and that he give from his honor to them, in order to illuminate them with his Torah study. He refused their offers, and rejected them out of fear that in a large town his service of God would be compromised. For this [service of God] was his entire goal and desire, and he was disgusted with any material affairs. When he prayed in the evening and morning he would isolate himself in a special room he used for the study of Torah and service [of God]. Even when I visited him and spoke face to face with him (for such was the deep affection we had for each other, as all know), he would demand that I leave his room when it came time for his pure prayers, and I would fulfill his request. Last winter I was in his home when a question about the *kashrut* of a goose arose, and he requested that I listen to the question and that I make a ruling. I examined the knife, and I was concerned about a specific perforation in the intestines. (I could not be sure if the perforation was made with the knife or was natural.) We discussed the matter at great length until we agreed that the animal was not kosher. He then asked the boy who had raised the question to whom the goose belonged. He replied that it belonged to his mother, who sold milk [in the town]. He then gave the boy two franks that he should give to his mother, and told him to tell her that he [R. Landau] would buy milk from her. The boy was overjoyed and gave thanks and praise to God, Blessed be He, that He had taken this goose from him. [R. Landau] often said to me that he would suffer greatly if he had to rule an animal not kosher and its owners would refuse to take money from him. Now I could go on recounting his great deeds . . . woe to us who have lost such a leader, the crown on our heads. . . . (See "Hesped," in *Degel Mahaneh Reuven* [Chernovtsky, 1884], 39-40.)

7. At the end of the second section of *Mahalakh ha-Kokhavim* (see further about this work), R. Landau identifies the names of his parents as Yizhak and Hannah.
8. There are a number of variant spellings of this town including Podu Turculi and Podul-Turcului. The town is located approximately 137 miles northeast of Bucharest. It was originally settled by Jews around the year 1827, and the Jewish population reached almost 1,100 by the year 1899. The town had two synagogues, as well as a number of professional societies, and most of the Jewish population was involved in trade. With the building of railway connections between local towns, Paduturk became a far less important commercial centre, and the Jewish community declined as a result. Prior to the outbreak of the Second World War, there were fewer than 480 Jews living in the town. The Jewish population of the town was rounded up on Saturday, June 20, 1941, and fewer than a quarter of the Jewish population returned after the war. There are currently no known Jews living in the town. The last recorded Jewish burial there occurred in 1952. See *Pinkas ha-Kehillah*, vol. 1 (Jerusalem, 1970) 200-202, and the International Association of Jewish Genealogical Societies Cemetery Project available at <http://www.jewishgen.org/cemetery/e-europe/rom-p-r.html> (accessed May 18, 2006).
9. Although no date appears on the title page, the recto contains an approbation from R. Isaac Friedman, dated Tuesday, 4 Shevat 5642, corresponding

to January 24th, 1882. We can therefore assume that the book appeared sometime in that year. One other earlier book had the same title, *Mahalakh Ha-Kokhavim*, by Efrayim Mizraḥi of Turkey, composed ca. 1500. This work was a Hebrew translation of Georg Peurbach's *Theoricae Nova Planetarium* (*New Theories of the Planets*) which had been published in 1473. R. Moses Isserles (Rama) wrote a commentary on Mizraḥi's book.

10. *Mahalakh ha-Kokhavim*, introduction, 2b.
11. R. Landau is referring here to the nineteen year *maḥzor katan*. In the Jewish calendar, every nineteen years contains twelve regular and seven leap years. After nineteen tropical years, both the sun and the moon return to the same positions that they occupied on the ecliptic. This cycle, known to the Greeks and probably the Babylonians, is called the Metonic Cycle, after the astronomer Meton who introduced it in Athens in approximately 432 B.C. See J. James Evans, *The History and Practice of Ancient Astronomy* (New York, 1998), 185ff.
12. *Mahalakh ha-Kokhavim*, 1-2. An opinion in the Talmud interprets Deut. 4:6, “. . . for it [the Torah] is your wisdom and understanding in the eyes of the nations . . .” as referring to the calculation of seasons and constellations (*Shabbat* 75a).
13. See the unnumbered title page to the second part of *Mahalakh ha-Kokhavim*.
14. *Mahalakh ha-Kokhavim*, part 2, 6a.
15. Copernicus, *De revolutionibus orbium coelestium*, I,9.
16. *Mahalakh ha-Kokhavim*, part 2, 7b-8a.
17. *Ibid.*, 4-14.
18. Galileo devised a famous anagram which cryptically described his discovery, which when deciphered read : “*Cynthiae figures aemulatur mater amorum*—The Mother of Love (Venus, named after the Roman Goddess of Love) imitates Cynthia (an epithet for the Greek Goddess of the moon)” or, less cryptically, “Venus has phases like the moon. . . . [W]hat is happening is that it [Venus] is sickle-shaped and its horns are not only very thin but are also receiving the sunlight obliquely; hence this light is very dim in intensity and little in amount, and consequently its irradiation is less than when the planet's hemisphere appears entirely illuminated. On the other hand, the telescope clearly shows us its horns as clear-cut and distinct as those of the moon. . . .” See Maurice A. Finocchiaro, *Galileo on the World Systems: A New Abridged Translation and Guide* (Berkeley, 1997), 242.
19. Although it should have been possible to see similar phases of Mercury, the planet was too close to the sun, and Galileo's telescope was not powerful enough to observe these phases. As early as the 1630s there were claims that the phases of Mercury had been seen, but these observations were actually spurious, and caused by faulty use of the telescope itself. See Mary Winkler and Albert Van Helden, “Johannes Hevelius and the Visual Language of Astronomy,” in *Renaissance and Revolution: Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe*, ed. J. V. Field and F. A. J. L. James (Cambridge, England and New York, 1993). The first reliably detailed observations of Mercury were not made until after R. Landau's death and it is not clear whether R. Landau knew that the phases of Mercury had not been accurately observed.
20. *Mahalakh ha-Kokhavim*, part 2, 14a.
21. *Ibid.*

22. Ibid. Again, this argument from probabilities seems closely to follow the Copernican train of thought. Copernicus needed to deal with the objection that if the earth moved, the rapidity of its motion would be so great that the earth would long ago have been destroyed. Early on in *De revolutionibus* (1:8) he denied that the earth would indeed be destroyed by such rotation, and argued that the required movement of the planets at huge speeds, as proposed in the geocentric model, clearly does not lead to their destruction. He ended this section by stating that his arguments “. . . made it more likely (*omnibus probabilior*) that the earth moves than that it is at rest” (ibid).
23. *Mahalakh ha-Kokhavim*, part 2, 20b.
24. Ibid., part 2, 19a.
25. Richard J. Blackwell and Paolo Antonio Foscarini, *Galileo, Bellarmine, and the Bible* (Notre Dame, IN 1991), 122.
26. R. Moses Sofer, *Kunteros Kiddush ha-Hodesh*, chap. 3, part 1. This work is published from a manuscript that was in the possession of his son R. Shimon Sofer. Reprinted in *Po'al Hashem* (Bnei Brak, 1997).
27. *Mahalakh ha-Kokhavim*, part 2, p. 19a.
28. JT *Sanhedrin* 2:5. Variations on this story, together with the same phrase, also appear in *Shemot Rabbah* 6 and *Midrash Tanḥuma*, *parashat Va-era* 5. Moses uses the phrase in another story told in *Devarim Rabbah*, *parashat va-Eṭhanan*. See *Midrash Devarim Rabbah*, ed. Saul Lieberman (2nd. ed., Jerusalem, 1940), 40.
29. *Teshuvot ha-Rashba*, I, #98.
30. *Mahalakhah ha-Kokhavim*, part 2, 19b.
31. Ibid.
32. Copernicus, *De Revolutionibus* 1:10.
33. See Angus Armitage, *Copernicus and Modern Astronomy* (Mineola, NY, 2004), 217-18. “The phenomenon of annual stellar parallax, established (latterly with the aid of photography) for hundreds of stars, constitutes a classic proof of the earth’s orbital motion; the only alternative hypothesis would involve the revolution of the stars themselves in annual orbits in phase with the sun”.
34. *Mahalakh ha-Kokhavim*, part 2, 20a.
35. *Epistolarum Astronomicarum Liber Primus* (Nuremberg, 1601). Reprinted in *Tychonis Brahe Dani Omnia*, vol. 6, ed Johan Dreyer (Copenhagen, 1919), 218-23.
36. *De revolutionibus*, 1: 8.
37. Finocchiaro, 155-70.
38. For a full discussion of the arguments from common motion, falling bodies and cannon balls, see Edward Grant, “In Defense of the Earth’s Centrality and Immobility: Scholastic Reaction to Copernicanism in the Seventeenth Century,” *Transactions of the American Philosophical Society*, 74 (1984): 1-69, esp. part IV. See also Carla Palmerino and J.M. Thijssen (eds.), *The Reception of Galilean Science of Motion in Seventeenth Century Europe* (Dordrecht, 2004).
39. Galileo Galilei, *Dialogue on the Great World Systems*, trans. Thomas Salusbury (Chicago, 1953), 144.
40. *Mahalakh ha-Kokhavim*, part 2, 20b.
41. Ibid. As was pointed out by an anonymous referee, R. Landau’s chronology is inaccurate, for Tycho was born in 1546, three years after the death of Copernicus.

42. *Mahalakh ha-Kokhavim*, part 2, 21b.
43. Michel de Montaigne, *The Complete Essays of Montaigne*, trans. Donald M. Frame (Stanford, CA, 1986), 429.
44. Rashi, *Ketubbot* 57a, s.v. *mai kamashma lan*. See also Eliezer Berkovits, *Not in Heaven: The Nature and Function of Halakha* (New York, 1983), esp. chap. 2.
45. Landau, part 2, 20b.
46. Most of the major museums of science have a working model of Foucault's pendulum. The Smithsonian Museum of American History in Washington D.C. housed a seventy-one foot pendulum, under which the earth moves 226 degrees in twenty-four hours. It was removed in 1998 to make room for the Star Spangled Banner Preservation Project. A larger model can be found in the lobby of the United Nations General Assembly Building in New York.
47. This paper was part of his Ph. D dissertation titled "Nieuwe bewijzen voor de aswenteling der aarde" (New Proofs of the Rotation of the Earth).
48. Although Foucault did not actually prove that the earth moves around the sun, his experiment is considered to be the first to demonstrate that the earth moves. As such it provided the heliocentrists with clear evidence that it is the earth, and not the sun, which moves. See Amir D. Aczel, *Pendulum: Léon Foucault and the Triumph of Science* (New York, 2003); Aczel and William T. Vollmann, *Uncentering the Earth: Copernicus and the Revolutions of the Heavenly Spheres* (New York, 2006) 101-103. This is not quite the full story, however, for observations made in the early seventeenth century had suggested that the earth was moving, although a geocentrist could explain these same observations in a quite different manner. For example, it was shown that the meridian line in the Church of San Petronio in Bologna had shifted in relation to the Church. "An earth-centered person would think that the earth's axis had held steady and that the direction of rotation of the entire heavens had changed; whereas the sensible and modest Copernican would attribute whatever motion occurred to the mobile earth." See J. L. Heilbron, *The Sun in the Church: Cathedrals as Solar Observatories* (Cambridge, MA, 1999), 177. In 1675 the Danish astronomer Ole Römer suggested that light traveled at a finite speed. This radical hypothesis was part of a solution to the question of why the Jovian satellite Io made a series of late appearances. His explanation depended both on this suggestion and on a further supposition that the earth revolved around the sun. (See R. J. Mackay and R.W. Oldford, "Scientific Method, Statistical Method and the Speed of Light," *Statistical Science*, 15 (2000): 254-78.) Finally there was the work of the German astronomer and mathematician Friedrich Bessel, who is best remembered for his calculations of stellar distances based on measurements of parallax. All calculations of stellar parallax assume of course, that the earth orbits the sun. Bessel was awarded the Gold Medal of the Royal Astronomical Society for his work a full decade before Foucault's Parisian demonstration. See Anton Pannekoek, *A History of Astronomy* (New York, 1989), 342-43.
49. Landau, part 2, 21a (emphasis added).
50. *Middah Berurah*, introduction, 2b-3a.
51. *Mahalakh ha-Kohavim*, p. 1.
52. See JT *Ketubbot* 25:2. R. Landau's reference to JT, *Rosh Hashanah* is erroneous.
53. *Mahalakh ha-Kokhavim*, part 2, 26b.
54. Pinḥas Horowitz, *Sefer ha-Berit ha-Shalem* (Jerusalem, 1990), 152.

55. *Ibid.*, 154.
56. *Ibid.*, 50.
57. Tuviah Cohen, *Ma'aseh Tuviah* (Venice, 1708), 53.
58. David Nieto, *Matteh Dan ve-Kuzari Sheni* (London: 1714), part IV, 127-29. See also Jacob J. Petuchowski, *The Theology of Hakham David Nieto: An Eighteenth-century Defense of the Jewish Tradition* (New York, 1970), 59-63.
59. Rosenbloom, "Ha-enziklopedyah ha-Ivrit ha-Rishonah: Meḥabberah ve-Hishtalshelutah," *Proceedings of the American Academy for Jewish Research*, 55 (1988): 15-65. This accolade is not, however, accurate. In 1788 Baruch Lindau published *Reshit Limmudim* in Berlin, a Hebrew text book containing sections on astronomy, physics, biology and geography. The book was plagiarized by Simon ben David Oppenheim and published as *Ammud ha-Shaḥar* in Prague in 1789. Both preceded the publication of *Sefer ha-Berit*.
60. *Mahalakh ha-Kokhavim*, part 2, 20a.
61. Horowitz, 152.
62. *Sefer ha-Berit* was widely read in the nineteenth century and had been acknowledged as the source for material by at least two other writers. See I. Amaragi, *Darkhei ha-Adam* (Thessaloniki, 1843), who acknowledged copying much of part 2, chap. 13, and J. Riswasch, *Shevilei de-Rakia* (Warsaw, 1896), 21-22, who used part 1, chaps. 1 and 10. These authors, unlike R. Landau, openly acknowledged their debt to *Sefer ha-Berit*. As but one example of its widespread dissemination, the great scholar of Judaica, Solomon Schechter, recalled studying from *Sefer ha-Berit* as a young boy in Romania. See Schechter, *Seminary Addresses and Other Papers* (Cincinnati, 1915), 2.
63. Horowitz, 154. For a detailed analysis of the astronomy of *Sefer ha-Berit*, see Noah Rosenbloom, "Diyyunim Kosmologiyim ve-Astronomiyim be-Sefer ha-Berit," *Proceedings of the American Academy for Jewish Research*, 62(1996): 1-36.
64. Horowitz, 152-53.
65. Tuviah ben Moses Cohen, *Ma'aseh Tuviah* (Venice, 1708).
66. For example see *ibid.* part 2, especially chaps. 2-4.
67. *Ibid.*, part 3, chap. 1.
68. David Nieto, *Matteh Dan ve-Kuzari Sheni* (London, 1714).
69. *Ibid.*, part 4, paragraphs 106-109. On this topic, see Norman Lamm, "The Religious Implications of Extraterrestrial Life," *Faith and Doubt* (3rd ed., Jersey City, NJ, 2006).
70. *Mahalakh ha-Kokhavim*, part 2, 25.
71. A second edition of *Matteh Dan ve-Kuzari Sheni* was published in Metz in 1780, and a third in Warsaw in 1865, and although it is not known which edition R. Landau used, the passages in question are essentially the same in all the later editions, except for a routine substitution of *ha-akum* (in the third [1865 Warsaw] edition) for *nokhri* (in the 1714 London and 1780 Metz editions). This of course provides no substantiation for R. Landau's suggestion that the entire passage was forged.
72. The first, *Luḥot ha-Ibbur* (Leiden and Hanover, 1756), contained the astronomical tables needed to make the Jewish calendar and was the first Hebrew book printed in Hanover.
73. Raphael Halevi Hanover, *Tekhumat Ha-Shamayim* (Amsterdam, 1756).
74. Landau part 3, chap. 2, 4ff.
75. Maurice A. Finocchiaro. *Retrying Galileo, 1633-1992* (Berkeley, 2005), 193.

76. R. David Friesenhausen. *Mosedot Tevel* (Vienna 1820). For a brief description of the life and works of Friesenhausen, see Shnayer Z. Leiman, *Rabbinic Responses to Modernity* (New York, 2007) 22-32, also in Berger, Blidstein, Leiman, and Lichtenstein (n. 4 above; see pp. 158-64). Friesenhausen composed what I believe to be the only Shabbat *zemer* to describe the Copernican solar system, but I have yet to find its tune.
77. Ḥayyim Zelig Slonimski, *Kokhava de-Shavit* (Vilna, 1835), fourth page of the mispaginated introduction.
78. Joseph Ginzburg, *Ittim la-Binah* (Warsaw, 1889), 6-7.
79. Dov Ber Rukenstein, *Mesolot ha-Me'orot* (Lvov, 1898), pt. II, 1.
80. Although there were certainly rabbinical geocentrists who predated R. Landau, there were not many who were his contemporary. One example of such a person was Israel David Schlesinger (1802-1864), who among other works wrote *Ḥazon la-Mo'ed* (Pressburg, Anon Schmid 1843), on astronomy and the structure of the calendar. Schlesinger also wrote a commentary on *Bereshit* entitled *Yafe'ah le-Ketz* (Pressburg, 1862), in which he condemned Copernican thought as false. Schlesinger based his opinion on the comments of his teacher Ḥatam Sofer. See *Yafe'ah le-Ketz*, p. 7 and *Ḥazon la-Mo'ed*, 12b-13a.
81. Thomas S. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Cambridge, 1957), 191.
82. For some examples of the use of this principle, see Jim Holt, "The Laughter of Copernicus," in *Year Million: Science at the Far End of Knowledge*, ed. Damien Broderick (New York, 2008), 1-20.