question of the earth's annual motion. Freudenthal, however, arguing on the basis of Gilbert's cosmological diagram, doubts the veracity of this claim. "Gilbert's diagram of planetary motion," he writes, "which avoids tracing any circle through the sun or the earth, in fact implicitly precludes the geocentric model. If the sun with the planets, as represented in the diagram, were taken to revolve around the earth, it would penetrate the zone of the fixed stars; that is, there would be an observable annual parallax."[28] Furthermore, outside the orbit of Saturn, Gilbert, like Thomas Digges before him, fills his sky with stars no longer fixed within an outer closing sphere. He appears to give no indication of how he thinks of this outer region of stars, all of them the same, it would seem, in printed versions of this text, which give this illustration in black and white. Gilbert's half-brother, however, presented to the young Prince Henry a handsome bound manuscript copy of Gilbert's text in which this illustration is delicately colored.[29] In it the sun at the center of our universe, together with the reflecting moon, is done in fine gold leaf; and in the same leaf some, but not all, the stars in the outer universe glitter like other suns. So it would seem that Gilbert is endorsing Bruno's idea of multiple solar systems in which ever more distant earths move around their central suns, even if Gilbert, like Galileo after him, refuses in the *De mundo* to make any explicit statement on the question of infinity.

28. Freudenthal 1983:35.
29. British Library, Royal and Kings Mss., 12.F.XI, f. 88.

6 The Infinite Universe

When Copernicus put the earth in movement, both around its own axis and around the sun, he radically changed the terms in which the mind contemplated universal space. From a solidly heavy and central earth, the traditional cosmology had seen a closed sky of stars and planets attached to massive celestial orbs revolving around it. Copernicus, on the other hand, accentuated the smallness and lightness of the earth, whose agile revolutions seemed to him so much more natural than the cumbersome revolutions of the enormous mechanism of solid orbs around a central earth. Although maintaining the concept of solid revolving orbs, Copernicus envisaged the outermost orb of the fixed stars as lying at a far greater distance from earth than the traditional cosmology had allowed. Without denying the idea of a closed world, Copernicus could thus talk of an "immense" universe that *appears* infinite and with respect to which the moving earth now seems like a tiny finite point. This new cosmological perspective is outlined by Copernicus in the sixth chapter of the first book of *De revolutionibus* titled "Of the immensity of the sky with respect to the size of the earth." It immediately led to a lively revival of a debate, begun in classical antiquity and continued with fervor throughout the Middle Ages, as to whether God could create or had created the universe of finite or infinite dimensions.[1]

The importance of Bruno's reading of Copernican heliocentricity within the post-Copernican cosmological discussion was once amply recognized

1. Duhem 1913–59 follows this discussion, claiming the continuity between medieval and early modern science. The classic discussion of the change from the idea of a closed to an open universe is in Koyré 1957.

by a long line of distinguished historians of science, from William Whewell to Alexandre Koyré, but recently it has been underestimated or ignored in the light of Yates's claim that for Bruno the Copernican diagram "is a hieroglyph, a Hermetic seal hiding potent divine mysteries of which he has penetrated the secret."[2] His extension of Copernican heliocentricity to a universe of infinite dimensions, on the other hand—the philosophical importance of which Dorothea Singer finely stressed in her translation of the *De l'infinito*—has remained at the center of much comment even in the post-Hermetic discussion of Bruno. For the Hermetic interpretation of Bruno's works writes off his Copernicanism as a "hieroglyph" but concedes ample attention to his infinite universe as a place of expanded, mystical gnosis: the gateway to reconciliation with the divine principle and cause. Such an interpretation of Bruno's infinitism can be accused of being off the mark. For if there is no doubt that it is through his concept of universal infinity that Bruno proposes reconciliation with the divine intelligence, it is less certain that Bruno's infinite universe was constructed entirely, or even primarily, on the basis of Hermetic sources. Robert Westman, in his reply to the Yatesian Hermetic interpretation of Bruno, demonstrated convincingly that the Hermeticists of the sixteenth century shared no common cosmological picture.[3] Moreover, the more recent comparisons of Bruno's cosmology with those Hermeticists who did extend the universe to infinity have all pointed out the differences between the Hermetic concept of universal infinity, which was essentially neo-Platonic with clearly theological implications, and Bruno's infinite physical space populated with an infinite number of worlds.[4]

Bruno's infinitism is one of the guiding axioms of his philosophy and is continually recalled throughout his philosophical works. It receives its definition and philosophical formulation above all in three major texts: the post-Copernican Italian dialogue *The Ash Wednesday Supper* (1584), the slightly later dialogue, also in Italian, *On the Infinite Universe and Worlds* (1584), and finally the Latin *De immenso* (1591). In all these works, the infinite universe is seen as an extension of the Copernican heliocentric cosmology, and therefore as intimately related to Bruno's reading of Copernicus himself. The relationship between Bruno's Copernicanism and his infinitism changes in the course of his philosophical development. In the Italian dialogues, Copernicus's heliocentric astronomy is praised before the Nolan proposes his vision of an infinite universe and

2. See Yates 1964:241.
3. See Westman 1977.
4. I shall be referring in particular to Granada 1992 and 1997, and Vasoli 1991.

appears clearly as its foundation and conceptual base. In the Latin *De immenso* ancient and modern pre-Copernican precursors of the infinite universe are given far more prominence; and the Copernican astronomy itself, although far from being disregarded, is encapsulated as a stage in the Nolan meditation on infinity rather than as its historical or conceptual basis. In spite of this later modification, however, Bruno's infinitism remains intimately embedded in his study of Copernicus. The new, astronomically defined heliocentricity, linked to his reading of Telesius, allowed Bruno to develop a concept of an infinite universe composed of an infinite, homogeneous substance in which cold earths revolve around hot suns to guarantee the process of universal life. This idea of cosmic infinity, involving an infinite number of solar systems, is essentially different both from that proposed by the ancients and from the Hermeticists, as well as from the theologically defined infinitism of neo-Platonic precursors such as Nicholas of Cusa.[5]

The first mention of the infinite universe in *The Ash Wednesday Supper* is found in Dialogue 1, immediately after the page of generic praise of Copernicus himself. It is couched in the form of a celebration of a new form of infinity which the Nolan philosophy proposes to elaborate on the basis of the newly heliocentric universe put forward in the *De revolutionibus*. Just as Bruno's first mention of the sun as center in his early *De umbris idearum* was proposed in decidedly Hermetic terms, without precise scientific connotations, so the first mention of infinity tends to suggest a Hermeticized intuition of an infinite region of the soul: the infinite space in which the soul can search for its reconciliation with the divine:

> We recognize many stars, many astral bodies, many protective spirits, which are those hundreds and thousands who accompany us in our praise and contemplation of the first, universal, infinite, and eternal efficient cause. Our reason is no longer imprisoned by the bands of the imaginary eight, nine, and ten revolving orbs. We understand that there is one sky, an immense ethereal region, where these magnificent lights keep their proper distances in order to participate in eternal life. These flaming bodies are ambassadors who announce the excellence of the glory and majesty of God. In that way, we are led to discover the infinite effect of the infinite cause, the true and living image of infinite power.[6]

5. The classic treatments of Bruno's infinitism are to be found in Koyré 1957 and Michel 1962/1973. Also important are Singer 1950; and Greenburg's introduction to his translation of *The Cause, Principle, and One* (Greenburg 1950).
6. See Bruno 1958:34, and Bruno 1977:90–91. The translation here is my own.

To understand Bruno's thought on universal infinity correctly, it is important to realize that within what appears at first sight, in this passage from *The Ash Wednesday Supper*, a purely mystical, even cabalistic, celebration of the infinite, Bruno inserts one phrase which indicates the more scientific train of thought he will develop in the following pages of his dialogue.[7] This is the reference to the "imaginary bands": that is, the external spheres of the fixed stars, and beyond, which closed the traditional universe within finite dimensions. Bruno uses the plural here because, as we have seen, the increasingly urgent problem of precession was being solved in his time, within the traditional Ptolemaic scheme, by the addition of a ninth and even a tenth sphere outside the eighth sphere of the fixed stars. These extra spheres, however, were also rigorously defined as closed and, in Bruno's opinion, only supplied extra conceptual prisons with which to suffocate the mind.

In his essay "The Greek Theory of the Infinite Universe," David Furley has shown that the ancient debate on universal infinity was characterized throughout by the argument as to whether something existed outside the "band" defining our own world.[8] One of the earliest and most colorful expressions of this argument was that of the Pythagorean Archytas, who, in the fourth century B.C., asked: "If I were at the edge of the world, as it might be in the region of the fixed stars, could I stretch out my hand or a stick into the outer region or not?"[9] Furley demonstrates how this idea of an "edge" of the world pervaded all ancient thought, even among those philosophers, like the Pythagoreans themselves, who put forward the idea that there *was* something outside the outermost sphere of stars.[10]Richard Sorabji, writing on the same subject, claims that the best answer to Archytas came from Alexander of Aphrodisias (in *Questiones* 3.12:106, 35–107, 4), who argued for the impossibility of stretching the hand into nothing, an argument taken up by Bruno himself (although without mentioning Alexander).[11] Hippocrates' idea of a living universe envisaged the world as a "creature" enclosed within a living membrane or skin; while the Stoics thought of infinity as an empty space outside the boundaries of

7. For Bruno's use and reading of the Hebrew cabala, see De Léon-Jones 1997.

8. See Furley 1981.

9. Simplicius, *In Physica*, 467.26ff, quoted ibid., 578.

10. Furley 1981.

11. See Sorabji 1988, chap. 8: "Is there infinite or extracosmic space? Pythagoreans, Aristotelians and Stoics," and Bruno 1958: 371, where the moderately neo-Aristotelian Butchio, in the *De l'infinito*, says: "se uno stendesse la mano oltre quel convesso . . . quella non verrebe essere in loco, e non sarebe in parte alcuna, e per consequenza non arebe l'essere."

the fixed stars.[12] Even the Democritean idea of the world as a microcosm, which was particularly congenial to the atomistic philosophy, saw our one world as a bounded version of the larger cosmic whole.[13] The atomic view was thus no exception, in Furley's opinion, to the terms in which the ancient debate on infinity was conducted. The Epicurean Lucretius used the image of our own world as a walled city *outside which* an infinite number of other worlds reeled around in a terrifying cosmic dance.[14]

The discussion of universal infinity in the Hermetic texts takes place within this classical context of thought. A quotation from the *Asclepius* which Yates used to define Bruno's idea of universal infinity makes this clear: "For as the space outside the world, if it exists (which I do not believe) must be, in my opinion full of intelligible beings, that is beings like the divinity of that space, so the sensible world is absolutely full of living beings."[15] Not only is Hermes here taking up a position which is explicitly traditional and conservative with respect to the radical infinitists such as the atomists, he is also positing an essential difference between the bodies that inhabit a possible space outside the world ("which I do not believe") and those in the sensible world. The "outside," for Hermes, is (possibly but improbably) "full of intelligible beings" who can be identified with the divinity of outer space. Our own world is full of sensible beings which Hermes, like Plato, sees as also alive and imbued with sparks of divinity, but, at the same time, as infinitely distant from the full intelligibility of divine being which begins beyond the fixed stars.

This concept, which is so essential to ancient discussions of universal infinity, is present even in the eloquent passage from another Hermetic text, the *Pimander*: the passage where the Magus man "leant across the armature of the spheres, having broken through their envelopes."[16] The concept here, which is essentially neo-Platonic, is that the magical doctrine of correspondences between the various grades of being allows the well-indoctrinated mind to cross the boundaries. Yates states that this is

12. See West 1971.

13. The atomists' view of infinity is clearly outlined, although in hostile terms, by Aristotle. See *Physics*, III, 4, 203b, 15–30.

14. Lucretius, *De rerum natura*, I, 1102; II, 1144; III, 16; V, 371, quoted in Furley 1981: 574.

15. See Yates 1964: 245 and Copenhaver, ed., 1992:87–88. Copenhaver's translation of this passage runs: "For just as that which is said to be 'beyond the world' (if there is any such thing, I do not believe that [it is void]) is full of intelligible things resembling it in divinity, as I take it, so also is this world that we call 'sensible' completely full of bodies and living things."

16. Quoted in Yates 1964:239.

what Bruno thinks too. She comments: "Bruno claims to be qualified as prophet and leader of the new movement because he has made an ascent through the spheres. Under the impression that the Copernican discovery has abolished the spheres to which the stars were formerly thought of as attached, he sees this as a breaking of those envelopes by which the Hermetic gnostic ascended and descended through the spheres."[17]

Our reading of Bruno's Copernicanism, however, has shown that Bruno never believed that the Copernican cosmology in its original formulation abolished the celestial spheres. He claimed that discovery for himself, arguing for it in precise terms, partly on the basis of precession, which, since Copernicus, could be explained as a slight movement of the earth's axis rather than as a lengthy revolution of a sphere of fixed stars, and partly, probably following Alhazen and also Jean Pena, on the basis of optical reasoning. The point about Bruno's reformulation of universal being in the wake of Copernican heliocentricity was that the ascent could now (theoretically) be a physical one into outer space, and not only of the mind, for there were no longer any envelopes to break through.

Bruno's infinite universe represents a conceptual rupture with the ancient discussion of universal infinity, including that in the *Asclepius*. The ancient discussion, as Furley has shown, was based on differing opinions as to what, if anything, lay "outside" the outermost sphere of the fixed stars. Bruno carries to its most radical conclusion his conviction of the essentially imaginary nature of that outer "band" to our own world. With the concept of bands, he eliminates any distinction between the kinds of being in the different parts of the infinite universe. This idea was accompanied by a frontal attack on Aristotle's doctrine of the hierarchies of the soul. In his answer to Nundinius's fourth proposition in *The Ash Wednesday Supper*, Theophilus claims in no uncertain terms that all the other globes in the universe "are earths, in no way different from our earth in species, but only greater or smaller." The movements of all these infinite bodies, continues Theophilus, are determined by the motions of their particular souls. When a shocked Nundinius asks him if he thinks of these souls as sensitive, Theophilus replies: "Not only sensitive, but intellective as well." At this point, narrates Theophilus, Nundinius fell silent and laughed no more.[18] What has happened here is that Bruno has floored Nundinius, who thought he was proposing, like Lucretius, a purely casual material universe that stretched out into infinity. On the contrary, Bruno

17. Ibid.
18. Bruno 1958:109–10.

is proposing a material universe imbued throughout with the order and intelligence of the divine mind.

This is quite a different idea from the infinitism of much Hermetic cosmology, as it is defined in the passage from the *Asclepius* quoted above. Scholars have demonstrated that the Hermetic infinity played an important role in sixteenth- and seventeenth-century cosmological discussion. It is becoming increasingly clear, however, that the Hermetic idea of universal infinity needs to be distinguished from the model put forward by Bruno. Relying still on the ancient concept of a band of fixed stars which might, or might not, have something outside it, the Hermetic texts allowed the development of compromise solutions which filled an infinite post-Copernican space with divine, intelligible beings, sometimes identified with the superior stars themselves. This was the solution proposed in England by the pro-Copernican Thomas Digges, whose infinite universe remained heterogenous insofar as a superior "outside," with respect to our own solar system, was seen as filled with stars imbued with the souls of angels and the elect.[19]

This peculiarly Protestant cosmological solution found a similar if not identical counterpart in southern Europe in the infinitism of the Italian Hermeticist Francesco Patrizi of Cherso. Patrizi's infinite universe has been the subject of an interesting and erudite comment by Cesare Vasoli, who emphasizes both the affinities and the differences of Bruno's and Patrizi's infinitism.[20] Taking as his central text the section of Patrizi's *Nova de universis philosophia* titled "Pancosmia," and in particular book VIII of that text, Vasoli underlines how Patrizi, like Bruno, was concerned to eliminate from a space that assumed infinite dimensions all the cumbersome physical and conceptual entities of the traditional cosmology such as the crystalline spheres with their necessary prime mover, together with a series of Peripatetic concepts such as *potentia*, privation or form.[21] Like Bruno, Patrizi considered his infinite universe a return to a more simple and natural habitat after the complicated mechanism of the "machina mundi" of the Aristotelian-Ptolemaic system inherited by Copernicus. Patrizi's universe, however, as Vasoli stresses, is based on the ancient distinction between a unique world and a surrounding, essentially different, "empyrean." Patrizi seems to have used the same ancient

19. For Digges's cosmology seen in its essential difference from that of Bruno, see Koyré 1957, Westman 1977, and Granada 1992 and 1997.
20. See Vasoli 1991.
21. There is no full-length English translation of Patrizi's text, but Brickman 1943 translates Patrizi's ideas about space.

sources as Gilbert: Stoic philosophy, with its idea of an infinite empty space beyond our own world, and the Hermetic texts which (insofar as they conceded physical infinity at all) filled up the extramundane space with divine light and life.[22]

Behind Patrizi's version of the infinite universe can be detected another Italian presence: that of Palingenius, author of the *Zodiacus vitae* published in Venice in 1531.[23] Palingenius's complex and often ambiguous text claimed for itself a Catholic orthodoxy that was belied by frequent strong attacks on the monastic culture of the time: an aspect of his work which gained him an enthusiastic public in northern Europe as well as an early translation into English.[24] Palingenius's work contains one of the most powerful renaissance reappraisals of Epicurean philosophy, although its Epicureanism, clearly derived from the poem of Lucretius, is curiously blended with a strong neo-Platonic and Hermetic strand of thought. Essentially an ethical work that underlines the good and bad characteristics associated with each sign of the zodiac, Palingenius's poem clearly wishes to establish a principle of pleasure and order within the natural universe. That principle, rather than being based on the casual agglomerations of Epicurean atoms, or even on the more pleasing cosmic whirlwinds of Democritus, calls rather upon a neo-Platonic concept of light: a natural light as the primal substance of a unique world and a divine light as the essence of the infinite space outside.

Bruno, like Patrizi, had read Palingenius with interest and admiration, although tempered with criticism that separates Bruno's infinitism both from that of Palingenius and of Patrizi. In chapter 6 of the eighth and last book of the *De immenso*, published in the same year as Patrizi's *De nova universis philosophia*, 1591, Bruno expresses his opinion of Palingenius in a chapter significantly titled "Palingenius dreams profoundly together with Plato when he thinks of infinite light deprived of body as lying beyond this finite world and beyond the visible stars."[25] Bruno claims here that his own concept of universal infinity is based on the idea of a continuum, which is a necessary logical conclusion of the idea of universal

22. The importance of Patrizi's ideas in sixteenth-century England, as well as those of Telesius and Bruno, has been underlined in Henry 1979 and Prins n.d.

23. For Bruno and Palingenius, see Granada 1992.

24. See Palingenius 1531 and 1565/1947.

25. *De immenso*, bk. VIII, chap. 4. As well as Platonic and Hermetic sources for what Bruno thinks of as a false infinity, he mentions more than once Heraclitus of Pontus both as an early exponent of heliocentricity and as the propounder of a unique universe with outside it an infinity composed of fire. For the astronomical fragments of Heraclitus, see Gottschalk 1980:chap. 4.

infinity as the expression of God's plenitude. If the infinite universe is the direct imprint of the infinite mind of God, then it cannot admit of interruptions between a material world of things and an immaterial world of pure, divine light. God's plenitude must be present and effective in all parts of the infinite whole. In a sense, then, the compromise solution of the post-Copernican sixteenth-century Hermeticists, who tried to fill up an infinite space with a neo-Platonic semimaterial and semispiritual element such as light, seems to Bruno as logically false as the traditional closed universe it attempts to replace. Not even Plato, Bruno notes, dared to suggest that the finite can be continuous with the infinite: incorporeal being cannot exist side by side with corporeal being because they have no common genus. Those who situate "another nature" beyond the visible stars are unable to produce demonstrable proofs and must be dismissed as wishful thinkers and dreamers.[26]

A universal continuum, in Bruno's opinion, must be founded on a homogeneous concept of substance. By the time Bruno wrote these pages of the *De immenso* he had already defined his universal substance in atomic terms in the first work of the Frankfurt trilogy, the *De triplici minimo*. His infinitism can be fully understood only in the light of his reproposal of ancient atomism. Here, however, we are interested in the connection between Hermeticism and universal infinity in the context of the post-Copernican cosmological discussion. What has emerged is not only that Bruno's infinitism was not founded on the Hermetic texts but that those texts were being used by many cosmologists of the period to authorize a compromise solution to the question of a post-Copernican universal infinity of which Bruno himself was highly critical.

The cosmology of Trismegistus remained safely anchored to the ancient concept of a unique universe bound by the circle of the fixed stars. Outside, if there was anything, was a spiritual entity leading the soul to God, the macrocosm, figured as an infinite circle with an unbounded circumference. In the *Asclepius*, Trismegistus urged his young pupil to turn away from the vicissitudes of the sensible world and, aided by the divine gift of reason, attempt to penetrate the higher truths of the spiritual garment that envelopes the sensible universe of man.[27] This Trismegistan dichotomy is echoed in a seventeenth-century text quoted by Furley: Walter Charleton's *Physiologia Epicuro-Gassendo-Charletoniana: or a Fabrick of Science Natural upon the Hypothesis of Atoms*. Although professing atomism, Charleton refuses to consider atoms as the substrata of

26. *De immenso*, bk.VIII, chap. 5. See Bruno 1879–91, I, ii:300.

27. See Copenhaver, ed., 1992:89.

an infinite universe. Rather, he calls piously on Trismegistus to justify a scientific inquiry sanely anchored, in Baconian terms, to the sublunar world:

> If any Curiosity be so immoderate, as to transgress the Limits of this All, break out of Trismegistus Circle, and adventure into the Imaginary Abyss of Nothing, vulgarly called the Extramundane Inanity; in the Infinity (or rather Indefinity) of which many long-winged Wits have, like seel'd Doves, flown to absolute and total loss: the most promising Remedy we can prescribe for the reclaiming of such Wildness, is to advertise, that a serious Diversion of thought to the speculation of any the most obvious and sublunary natures will prove more advantageous to the acquisition of Science, than the most acute metaphysical Discourse.[28]

It seems possible that the reference to "seel'd Doves flown to absolute and total loss" is a colorful but discreet way of recalling Bruno himself, particularly in view of Rita Sturlese's thesis that during his Copernican lectures at Oxford, rudely interrupted by the scandalized Oxford dons, Bruno was reading his Latin *Sigillus sigillorum*.[29] If so, Charleton's text could be considered an early misreading of Bruno; for Bruno does take from the Hermetic texts the idea of the world, even in its most humble material manifestations, as imbued with God-given life and intelligence. This divinization of matter, however, is an idea that Bruno applied rigorously throughout an infinite universe that has no bounds between a "lower" and an "upper" sphere of being: an idea the Hermetic texts refuse. It is therefore incorrect to speak of Bruno as experiencing in an infinite Hermeticized universe "an expanded form of gnosis." There can, in his universe, be no gnosis because no "higher" or "other" world is available to the mind of man. The mind, of course, contains varying degrees of knowledge of the infinite universe, but that is another question. Bruno made his rejection of the idea of a gnosis in his infinite universe explicit in his critical comment on Palingenius in the last book of the *De immenso*: Palingenius, it must be remembered, is praised as the thinker who had got closest to a correct idea of an infinite universe, but not, in Bruno's opinion, close enough. Commenting on Palingenius's conviction that the world derives from an evil principle, whereas God's will, expressed in the divine light that diffuses the universe beyond the band of fixed stars is the essence of justice and good, Bruno writes: "Although it is inappropriate to

28. Charleton's text, published in 1654, is quoted in Furley 1981:576.
29. See Sturlese 1994.

do so, if you wish to affirm that nature is the place of evil, you are obliged to admit that there exist two kinds of principles, and in that way you will gain the approval of the sect of the gnostics."[30] For this reason, Bruno finally put Palingenius aside and, in the final pages of the *De immenso*, celebrated his own idea of an entirely homogeneous, infinite universe, filled throughout with one constantly moving and modifying substance.

Recent criticism, as well as emphasizing the differences between Bruno's infinitism and that of the post-Copernican Hermetic cosmologies such as those of Palingenius, Patrizi, and Digges, has also been much concerned with Bruno's definition of the infinite world through a rigorous logical confrontation with Aristotle and the Christian theologians of the Middle Ages: a subject which had already been excellently treated by Hélène Vedrine in 1967. In a later major study of Bruno's "eclectic scholasticism," carried out in the wake of Charles Schmitt's reevaluation of renaissance Aristotelianism, Paul Richard Blum has underlined the importance for Bruno's intellectual formation of his teachers at the monastery of San Domenico Maggiore in Naples, and in particular of Matthias Aquarius.[31] Referring to Aquarius's annotated copy of the comment by Johannes Capreolus to the *Sentenze* of Pietro Lombardo, Blum has demonstrated that a strong interest in the question of the possible infinity of the universe was already present in the monastic Naples of Bruno's early years.[32] After considering, in the light of late-scholastic discussions, the problem of God's *potentia* with relation to his creation of the world, Aquarius rejects the infinite universe, although the terms of that rejection become increasingly ambiguous as the discussion wears on.

When Bruno reached Paris in 1581, he would already have been well versed in scholastic discussion of the infinite and may have paid particular attention there to the treatise on the subject published at the beginning of the century by the Scots logician John Major, active at the Sorbonne under the name of Jean Mair (1469–1550). In his complete treatise of logic published in 1506, Mair had inserted between a section of *Argumenta sophistica* and a *Dialogus inter duos logicos et magistrum* at the end of the volume, a series of *Propositum de infinito* divided into three questions: Is there an infinite in act? Is it contradictory that God produce an infinite creation? On the movement of an infinite body.[33] There are

30. *De immenso*, bk. VIII, chap. 6. See Bruno 1879–91, I, ii:302.
31. See Blum 1994.
32. For a more general account of the studies that Bruno would have been required to undertake during his monastic period in Naples, see Miele 1992.
33. For a modern French translation, see Mair 1938.

aspects of Jean Mair's treatise which suggest that Bruno knew it well: for example, that *Dialogus inter duos logicos et magistrum*, which takes the form of a neo-Aristotelian debate on formal scholastic propositions similar to those put forward by Nundinius in the central dialogue of Bruno's *Ash Wednesday Supper*. Theophilus's suggestion in the *Supper* that Nundinius himself had "gone into Scotland" may not refer to an actual journey but rather to Nundinius's association with the figure of Jean Mair, who also rejects the arguments in favor of an infinite creation on the part of God.[34]

Mair, however, excepts from this negative judgment an argument that he develops at length. That is the evidence of the spiral line, which he distinguishes from a circular line insofar as it fails to finish where it commenced but rather stretches in a cylindrical form into infinity. The spiral line, as Mair probably knew, was associated not only with spatial infinity but with temporal infinity as well. In a discussion in the pseudo-Aristotelian *Problemata*, the Pythagorean Alcmeon is described as saying that people die because they are unable to join beginning to end, a remark that seems to associate the spiral line with immortality through metempsychosis.[35] The spiral line thus authorized a series of highly unorthodox doctrines from a Christian point of view; and Mair has good reason to associate it with the serpent in the tree of knowledge.[36] When he comes to his final repudiation of the various arguments in favor of an infinite universe, Mair nevertheless admits that the spiral line holds meanings which are too potent for him to contradict, although he enigmatically refuses to explicate those meanings. Bruno himself adopts a very similar attitude when, in a much commented page of the *Heroici furori* the Neapolitan poet Tansillo (a historical figure belonging to a previous generation) also uses the spiral line to illustrate the movement of thought which, metaphysically, leads the mind through the grades of perfection until that infinite center is reached which is neither form nor formed. Tansillo's pupil, Cicada, asks how it is possible, moving in circular motion, to arrive at the center. Tansillo replies enigmatically that such motion exists, although, when pressed by Cicada, he refuses (as does Jean Mair) to explain his meaning further: "I can only tell you, and leave you to consider it."[37] Here scholasticism has been dissolved in neo-Platonic mysticism following an idea favorable to universal infinity; although it is not yet explicated in Bruno's more realistic cosmological terms.

34. "Però quanto a certa instanzia che produsse Nundinio de gli monti di Scozia, dove forse lui è stato, mostra che lui non può capire quello, che se intende per gli altissimi monti" See Bruno 1958:115.

35. See Sorabji 1988: chap. 10. Sorabji claims that the Pythagoreans and possibly also the Stoics thought about time as circular rather than linear. He further points out that the Great Platonic Year, which corresponded to the period at the end of which all the stars would have returned to their original positions (that is, the period of precession), offered an image of the reduplication of worlds in circular time.

36. "... la ligne circulaire se distingue de la ligne spirale en ce qu'elle finit au point où elle a commencé, tandis que la spirale finit au point opposé, comme le serpent dans l'arbre d'Adam": Mair 1938: 15.

Bruno's Spanish translator, Miguel A. Granada, has published an important study of Bruno's refusal of the traditional distinction between God's *potentia absoluta* and his *potentia ordinata*.[38] Granada demonstrates how the refusal of this distinction was at the basis of Bruno's extremely personal and original concept of physical infinity. The classical studies of Bruno's infinitism in Arthur O. Lovejoy's *Great Chain of Being* and Alexandre Koyré's *From the Closed World to the Infinite Universe* had emphasized the dependence of Bruno's idea of physical infinity on the logical argument known as the Principle of Plenitude. This argument states that an omnipotent God can only create an infinite world, infinitely full of being, because a finite world would represent a limit to divine power in the act of creation. Lovejoy and Koyré underlined how the Christian theology of the Middle Ages had opposed to this principle a series of restrictions designed to save the idea of divine free will in the act of creation: God freely decides to restrict his divine powers in the creation of a finite world in a definite moment in time. Granada, following an indication put forward by Alfonso Ingegno in his studies of Bruno's religious thought, points out that these theological restrictions were based on the conceptual distinction between *potentia absoluta* in God and *potentia ordinata*.[39] These were not defined as two different divine powers, but rather as two different ways of conceiving of divine omnipotence. God's creation, by virtue of his *potentia ordinata*, of a passive, finite material world through which he acts as the giver of forms, is the way he has chosen to express his *potentia absoluta*, and the distance between the two represents the possibility of divine intervention in the material world through the power of miracles.

The Hermetic forms of an infinite universe that preceded or were contemporary with Bruno denied this distinction, claiming that God's *potentia absoluta* required him to create an infinite universe. Going back to ancient Platonic and Aristotelian hierarchic concepts of being, however,

37. See Bruno 1958: 1012–3. This passage was the subject of some of the most famous pages of nineteenth-century Bruno criticism. See Bertrand Spaventa, "La dottrina della conoscenza di Giordano Bruno," *Saggi di critica*, 1867, 252–55.

38. See Granada 1944.

39. See Ingegno 1984 and 1987.

the Hermeticists filled up the higher regions of their infinite space with some divine substance such as light or intelligence, maintaining the idea of a unique material universe of finite dimensions. Bruno, as Granada demonstrates, expresses a far more radical refusal of the scholastic distinction between *potentia absoluta* and *potentia ordinata*. For Bruno, an all-powerful God can, as a logical necessity, express himself only in terms of a *potentia absoluta*, and therefore his entire creation will partake of the infinite, in this world and in all other worlds that exist within the infinite whole. There will be an end to the hierarchy of being. There will also be no more miracles because everything already corresponds to the *potentia absoluta* of God, and what appears inexplicable and marvelous will be due to the limited powers of the mind, anchored as it is to a specific place in space and time. Bruno insists on this motive with particular emphasis in chapter 1 of book I of the *De immenso*: "It is in the nature of humankind, and part of everyone's desire, to be able to embrace totality: everyone desires to be that which he is only at times; to see everywhere what he only sees in particular places; to consider in its universality what only appears to him in its singularity; to make full use of that which he can only use in part."[40] This cluster of ideas raises the problem, on which Bruno was not always consistent, of the existence of universal scientific laws: for example, the movement of all earths in the universe about their central suns.

Granada points out that Bruno's radical refusal of the scholastic distinction between the two forms of divine *potentia* leaves him with tricky problems to solve, the major one being how to explain the evidently finite dimensions of all that we experience in the phenomenological world. Granada's reply to this question concentrates, in my opinion, on one aspect only of Bruno's explanation, thus depriving his thought of much of its originality and complexity. The aspect which Granada correctly underlines is the logical distinction between divine *complicatio* and divine *explicatio* on which Bruno insists in his discussion of divine omnipotence. Bruno accuses the scholastic and Christian tradition of propounding an anthropomorphic concept of God, insisting on attributing to an omnipotent divinity such concepts as will, choice, and liberty, which are relevant only to finite minds. He claims instead that the absolute quality of God's infinity and power cancels such concepts. In God, choice and necessity, liberty and act, are contemporaneous and identical. It follows that in the world created by God's *complicatio*, all those elements which, in his *explicatio*, appear finite to our finite minds contain within them also

40. See Bruno 1879–91, I, i:202.

the infinity of God: "I say that God is *completely infinite*, because he excludes from himself every limit, and every one of his attributes is one and infinite; and I say that God is *totally infinite*, because his totality is in all the world, and in every part of it infinitely and totally."[41] Granada recalls Bruno's dependence here on the thought of Cusanus. Bruno, however, modifies Cusanus's doctrine by insisting that the material expression of the totally infinite is not assumed by the mediating figure of Christ, but rather by the infinite universe itself, which becomes the Word, a second God, the only mediator between the human mind and God.[42]

If Bruno's defense of his infinite world were to rest only on this logical concept of the *coincidentia oppositorum* in the mind of God, it could justly be accused of resting on a purely metaphysical basis. Much more physical consistency derives to it from the atomistic argument put forward by Bruno from the time of his Italian dialogues but reelaborated in the first work of the Frankfurt trilogy, the *De triplici minimo*, as the foundation of his concept of universal infinity as it will be defined in the *De immenso*. For the central characteristic of Bruno's atomism is the idea that every atom contains all the power and virtue of divine infinity. The atom is thus the ultimate receptacle throughout the infinite universe of the *potentia absoluta* of God: a concept that allows Bruno to identify the creative power of God with the maximum unity of the infinite universe and to conceive of both of them as infinitely compressed within each minimum unit or atom in a page which, as I have shown elsewhere, was being eagerly read in England by the scientists surrounding the ninth earl of Northumberland.[43]

> And yet we must affirm that finite matter, however extended, is not composed of infinite parts, but if we continue adding to it, like adding innumerable numbers to a finite number, then it really is possible to proceed to infinity. On the contrary, by subtracting and dividing the parts of a finite magnitude, we necessarily arrive sooner or later at the minimum quantity, just as by subtracting a number from a finite number we must arrive at the monad.[44]

And it was surely because Bruno had developed this "coincidence" between the infinitely small and the infinitely great that Harriot, in a letter

41. See *De l'infinito, universo e mondi*, in Bruno 1958:382.

42. For Bruno and Cusanus see Vedrine 1970, the relevant pages of Bernart 1986, and Ingegno 1987:113–33.

43. See Gatti 1989:60.

44. See *De triplici minimo*, bk. I, chap. 6, in Bruno 1879–91, I, iii:152–53; my translation.

of 1608 to a disapproving Kepler, could write his much-quoted passage: "I have led you to the doors of nature's mansion, where her secrets are hidden. If you cannot enter on account of their narrowness, abstract yourself mathematically, and contract yourself into an atom, and you will enter easily. And after you have come out, you will tell me what wonders you have seen."[45] Bruno's atomism solved for him the problem of explaining the apparently finite aspects of an infinite world. For if every aspect of being consists of a meaningful agglomeration of atoms, and if each minimum atom contains all the maximum power of God, then all matter is imbued with the absolute power of the divinity and finite only according to the subjective limitations in space and time of the perceiving qualities of the human mind.

> It is a long time since the death of a single time for all things, subjectively located in the highest heaven. . . . So, you will draw your conclusions with respect to the moments of time and the phases of movement, not starting from the point of view of the subject, given that the boundaries of one genus do not define the boundaries of another genus, and the time of one genus cannot be considered as unique with respect to the time of another.[46]

There were good reasons why post-Kantian philosophers such as Schelling, Coleridge, and Hegel were reading the works of Bruno.[47]

45. The correspondence between Kepler and Harriot was conducted in Latin. The entire exchange has been published in Kepler 1937–75, vols. 15 and 16. The English translation in my text is from Jacquot 1952. Kepler's correspondence with Harriot is also discussed in Shirley 1983: 385–88. The significance of Bruno's idea of the atom as not only a minimum quantity but at the same time a maximum source of energy was pointed out by Paul-Henri Michel in two important studies of Bruno's atomism. See Michel 1957 and 1964.

46. See *De triplici minimo*, bk. 1, chap. VIII, in Bruno 1879–91, I, iii:168; my translation. For an interesting comment on Bruno's treatment of time in the *Camoeracensis acrotismus*, see Capek 1987; and for a more thorough and profound if less scientific treatment of the same theme, Badaloni 1997.

47. See Beierwalters 1973/1983, Blumenberg 1975/1987:353–85, and Ricci 1991 for Schelling and Hegel. For Coleridge and Bruno, see Gatti 1996.

7 The Infinite Worlds

Developing a scholastic distinction, Miguel Granada has extended his important work on Bruno's infinite *extensiva* to his infinite *intensiva*, located in the infinite number of celestial worlds. Here and in the following chapter I suggest that Bruno's infinite *intensiva* was located ultimately in the infinite number of indivisible atoms, although he never abandoned the special status, accorded in the Italian dialogue *On the Infinite Universe and Worlds*, to the innumerable worlds as privileged agglomerations of atoms, which he thought of as infinite in number although finite in kind. The fact that finite body and finite dimension are the ways in which the human mind understands the physical universe must not, in Bruno's opinion, lead to the mistaken idea that finite dimensions are not real. The finite aspect of bodies is very real; for it is the way in which the divine intelligence intends them to be understood. Equally, the divine intelligence intends the universe as a whole as essentially infinite (both *extensiva* and *intensiva*), and that means that it really is infinite, and must be so. The infinity of the whole, Bruno writes in the second dialogue of *De l'infinito*, is even more necessary to a proper understanding of the universe than the finite nature of its parts.[1]

A necessary consequence of Bruno's thought about the principle of plenitude is that the infinite universe cannot be empty, either inside or

1. ". . . come realmente si trovano corpi dimensionati finiti, cossì l'intelletto primo intende corpo e dimensione. Se lo intende, non meno lo intende infinito; se lo intende infinito ed il corpo è inteso infinito, necessariamente tal specie intelligibile è; e per essere produtta da tale intelletto, quale è il divino, è realissima": Bruno 1958:395.

outside our own world. Although Bruno will sometimes describe his infinite space as nothing more than an infinite container subject to a tridimensional Euclidean geometry, it is in fact never, and in no part, to be seen as an empty container.[2] For Bruno fills his universe with an infinite material substance, which he calls by the traditional term "aer" or "ether." This ether must be continuous with the infinity of the universe itself; for, as we have seen, Bruno objects to any discontinuity within the infinite whole. How, then, is he to account for atoms? In the second book of the *De immenso*, Bruno approaches the problem in these terms: "The single atoms and species are limited, but all the atoms (according to the number of the indefinite average species and the prime definite species, which are the elements) are infinite and infinite is matter itself out of which all things are formed, and infinite is space in which all things are contained and limited, endowed with a finite activity and passivity."[3] Bruno places the infinite number of single atoms in an infinite ether which is identifiable with infinite space, and as such should be considered as logically prior to bodies in space. Within the all-pervading ether, an infinite number of touching minimums, or atoms, all containing a total divine potency, and not a part of that potency, emerge into finite forms like the formation of water drops from the immensity of the ocean. A first formation is seen as "prime" and gives rise to the traditional "elements." From these a second process of formation gives rise to discrete bodies. In Bruno's universe, however, no composite body is ever completely discrete. The occasional agglomerations of atoms, through constantly changing combinations of the elements, are always unstable, forming and reforming, condensing and dissolving.[4]

The active forming principle in this universe of constant vicissitude is located within the infinity of the infinite substance, its forming activity visualized by Bruno as a kind of universal yeast. This forming principle is identified by Bruno with soul. All soul in Bruno's universe is divine and therefore intelligent. There are no vegetative or even sensitive souls corresponding to the traditional Aristotelian hierarchy. The soul of a stone, with respect to that of an apparently higher body such as an animal or man, is not different in kind. It simply has a less fully articulated form than others, through the particular disposition of its atoms, of the substrata of infinite substance. Even that may be an erroneous judgment depending on our incapacity to understand the particular life form of stones. In book V, chapter 1, of the *De immenso*, Bruno insists on the negative consequences of attempting to determine the nature and measure of all things on the basis of human criteria. And he mentions in particular "certain stones" which are imbued with a particular force of attraction that defies the human senses: a clear reference to the magnetic properties of iron.[5]

It follows from these premises that Bruno will fill up his infinite universe with an infinite number of worlds. These are a logical consequence of the infinite number of atoms which, impregnated with what Bruno sometimes calls soul, sometimes a "vital fluid," constantly coalesce and dissolve into an infinite number of forms. His debt here to the ancient atomists is explicit and clear. In the final *De immenso*, he deliberately writes a Latin scientific poem in imitation of the Lucretian *De rerum natura*. Bruno's reading of Epicurean and Democritean atomism is cautious and critical, however. In the cosmological context, his criticism is especially evident in his treatment of the theme of the disposition in space of the infinite number of worlds. Referring to what he calls a "stupid" opinion attributed to Epicurus by both Diogenes Laertius and Lucretius, Bruno denies that the immense universe contains only one sun.[6] For Bruno, the logical consequences of the atomistic explanation of matter include not only an infinite, homogeneous substance as the basis of universal being, but also the formation of an infinite number of celestial bodies of a substantially similar nature throughout the infinite whole. Bruno calls these infinite worlds angels or gods insofar as they mediate between the finite human mind and the universal, infinite whole.

All the celestial bodies in space, including earth, are, in Bruno's opinion, closely related. With respect to the casual agglomerations of atoms, and the consequent casual disposition of bodies in space of the ancient atomists, this concept of an intimate universal order had been one of the keystones of Aristotelian cosmology and physics. Bruno recognizes its force and mediates through Aristotle's Arabian disciple Averroës his idea of matter as a permanent principle that, far from assuming its forms in a

2. "Space is a certain continuous physical quantity, in three dimensions, which contains everything indifferently . . . it stretches beyond everything and includes everything. . . . Space is not movable but gathers within itself the things which move": *De immenso*, bk. I, chap. 8, in Bruno 1879–91, I, i:231–32.

3. *De immenso*, bk. II, chap. 9, in Bruno 1879–91, I, i:291; my translation.

4. See in particular bk. V, chap. 1, of *De immenso*. Here Bruno doubts the ability of the rational finite mind to follow the intricate process of constant change and vicissitude which characterizes the infinite whole. He dwells in particular on certain inconstant forms such as the goat "elongated" by the kids that follow in her wake, or, once again, the spiral line that finds its image in the serpent with its shining, slippery back. For this aspect of Bruno's thought, see in particular chaps. 5 and 6 in Badaloni 1988:69–95.

5. See Bruno 1879–91, I, ii: 114–5.

6. See *De immenso*, bk. II, chap. 9 in Bruno 1879–91, I, 1:290.

passive, casual sense, constantly produces them from an internal intelligence dominated by an idea of order.[7] Yet Bruno knows that he must find a new conceptual foundation for the order of the cosmos, for he has already deprived his own universe of both a prime mover and of the idea that all motion is centered on earth. One possibility would have been to fall back onto a Christianized theological concept of universal order; and for this there was an authoritative model in the work of Nicholas of Cusa, whom Bruno read and admired.

Bruno's interest in the philosophy of Cusanus was probably owing to the clarity with which the fifteenth-century cardinal started his inquiry from the same problem that is at the source of so much of Bruno's cosmology. In his best-known work of 1440, *On Learned Ignorance*, Cusanus underlines the incommensurability between infinite and finite wisdom. According to Cusanus, divine and cosmic infinities remain out of line with man's finite conceptions. This intuition led Cusanus, in the second book of *On Learned Ignorance*, to propose a cosmic relativism that rejected the Aristotelian-Ptolemaic cosmology. For Cusanus denied the one universe centered on earth, claiming that the shadow and dark color of the earth could not justify its being placed at the bottom of universal being as the place toward which all things gravitated. Rather, Cusanus claimed that the sun was made of the same elements as earth and that throughout an infinite universe, without circumference or center, all celestial bodies are suns representing to the same extent the explication of God's creative power. Yet even when he had filled an infinite universe with divine light and had further proposed (with neo-Platonic echoes) an infinitising geometry based on the identity between the minimum arc and the minimum cord, or the infinite line and the maximum circle, Cusanus was unable to bridge the final gap between a human idea of infinity and the divinity of an infinite infinite beyond our understanding. It was on the basis of this intuition of a fundamental discontinuity and incommensurability that Cusanus justified the necessary incarnation of Christ.[8]

Much has been written on Bruno's open admiration of the "divine Cusanus" and his even more frequent, often unacknowledged, quotations from his works.[9] Bruno's cosmology has even been explained as a fusion of Copernicus's heliocentricity and the infinitism of Cusanus. We must

7. For Bruno's reading of Averroës, see Sturlese 1992a.

8. For the thought of Cusanus and its influence on Bruno, see Vedrine 1970.

9. See Tocco 1889:60, Cassirer 1927/1963, Ingegno 1987:113–48, and Bruno 1991a, where Sturlese underlines Bruno's use as a source not only of *On Learned Ignorance* but also of *De beryllo*.

not, however, overrate the influence of Cusanus. Although Bruno incorporated some important elements from Cusanus into his cosmology, his final estimate of Cusanus's work was as critical as his reading of, for example, the ancient atomists. The most articulate expression of Bruno's reading of Cusanus can be found in the third dialogue of *De l'infinito, universo e mondi*, where the subject of discussion is the matter out of which the sun is made with respect to the earth. Quoting from *On Learned Ignorance*, Bruno refers approvingly to Cusanus's doctrine of the essential similarity between the sun and the earth, composed, although in differing proportions, of the same elements. Bruno recognizes that Cusanus has already destroyed the Aristotelian cosmology, with its rigid distinction between the higher and lower regions of the universe, where he calls him "one of the most remarkable geniuses that have ever breathed under this air." He goes on to quote a further conviction of Cusanus that the earth and the moon, as well as the sun, should be considered luminous. Bruno says this is a doctrine which Cusanus could have done without, for he is filling his infinite universe, which is no longer divided into higher and lower spheres, with an infinite substance which itself is divided into two radically different elements: a subtle, ethereal, fiery matter which he considers an appropriate emanation of the divinity, and the more clearly material parts of the universe, such as the opaque face of the moon, which are fundamentally discontinuous with the divine light. Bruno comments that Cusanus, in his infinite universe, was like a swimmer struggling through tempestuous waves, sometimes high and sometimes low, with the added inconvenience of sudden interruptions between the crests of the waves and their troughs. Bruno instead proposes a serene and tranquil swim through a homogeneous infinity composed of a continuous substance within which fiery hot bodies, and cold opaque ones, are to be considered as different formations, though both of them ultimately derive from the unique substance that stretches out into infinity.[10]

Through this discussion of Cusanus, Bruno brings into prominence (again with shades of Pythagoras) a fundamental pair of contraries active throughout the infinite universal whole. These are fiery, hot substances and cold opaque substances. For Bruno, the genius of Cusanus lay in his perception that this dichotomy was not to be considered, in Aristotelian terms, as dividing the universe horizontally into two: a fiery celestial quintessence "up there" and a cold earthly solidity "down here." The fundamental dichotomy, for Cusanus, was discernible throughout

10. See Bruno 1958:440–42.

the infinite whole. This intuition deprived the universe of a center, making any center purely relative as a point of observation. His dichotomy, however, in Bruno's opinion, kept Cusanus at a distance from his transcendent God; for he was unable to accept that his universal dichotomies were founded on a principle of immanent universal unity from which they were constantly born and to which they constantly returned. Cusanus was therefore obliged to bridge his logically unbridgeable distance between unity and duality with reference to the incarnation of Christ: for only a miracle could resolve the unresolved play of contraries and contradictions in the phenomenological world. Bruno could solve his cosmological problem without reference to the Christian incarnation or to miracles, for he thought of his infinite, eternal substance as a direct explication of the absolute power and unifying principle of God.

By associating the two fundamental Cusanian contraries, light and shadow, with another pair of contraries in the form of heat and cold, Bruno was turning away from Cusanus toward the works of Telesius. In chapter 16 of the first book of his *De rerum natura*, Telesius had complained bitterly of the difficulties he had encountered in the publication of his work, which he must have found all the more galling as he had stretched his orthodoxy to its limits in an attempt to avoid the censures of the Catholic Church. Nevertheless, in the preface to his work, Telesius had declared himself willing to detract, if required, whatever the authorities might wish.[11] Furthermore, he never suggested that his doctrine of matter should be applied to any universe except the accepted one of Aristotelian-Ptolemaic fame. Nevertheless, the title of his work was provocative; and it must have been clear that his fundamental thermodynamic dichotomy could be extended throughout the material universe and not only applied to that part of elemental matter which lay beneath the lunar sphere.

Bruno took over Telesius's two "natural agents," heat and cold, in more strictly Lucretian terms than Telesius had dared to propose, in spite of the Lucretian title of his major work. Bruno applied them throughout to a universe of infinite dimensions composed of a homogeneous, material substance that founded the play of contraries in a unifying sense of the infinite whole. This use of Telesius's two basic natural agents, heat and

11. The two books of Telesius's *De natura iuxta propria principia*, published at Rome in 1565, were reissued in Naples with the title *De rerum natura* in 1570. The final text of Telesius's work, in nine books, was not published until 1586, in Naples. Although Bruno could not have known the complete work when he published his Italian dialogues in London between 1584 and 1585, Aquilecchia believes he had read it by the time he published his Frankfurt trilogy in 1591. See Aquilecchia 1993a:298.

cold, led Bruno to his most original contribution to modern cosmology: not only the idea that a universe of stars lay beyond our own sphere of outer stars but that these further stars must themselves be ordered into systems similar to our own system of planets revolving around a central sun. Bruno divided all celestial bodies into hot or luminous bodies, or suns, and cold opaque bodies that revolved around them to obtain their life-giving heat and light. He thought that all stars were suns, with bodies revolving around them so small that the eye could not detect them. Although this idea can hardly be said to correspond to the modern galaxy, it was certainly getting close. Bruno already thought not only that other worlds or star systems existed outside our own, stretching toward infinity, but that those worlds must be modeled on principles similar to the ones that defined the order of our solar system.

The thermodynamic principle, mediated through Telesius, which united all the infinite worlds into coherent order and forms was of great importance to Bruno because it supplied him with a biological explanation of the movements of an infinite number of worlds throughout an infinite space. To discuss Bruno's cosmology without reference to the thermodynamic principle mediated through Telesius leads to what appears to me the serious error, so often repeated in Bruno criticism, that his infinitism was not a properly cosmological concept but only the place in which to experience a kind of religious *enthusiasmus*, or perhaps a more rational contemplative neo-Platonic ascent of the soul. This interpretation has a long history, going back at least to the puzzled reading of Bruno's post-Copernican cosmology by nineteenth-century scientific commentators such as Schiaparelli, referred to by Felice Tocco, who could not understand how a properly astronomical argument could be expressed in the exuberant mythical and metaphorical language so often used by Bruno.[12] It received strong endorsement from the Hermetical school of Bruno scholars, and in particular from Frances Yates, whose 1964 book significantly makes no mention of Telesius's thermodynamic theory of matter.[13] Alfonso Ingegno and Miguel Granada have also been

12. The distinguished astronomer Giovanni Schiaparelli was consulted by Felice Tocco to illuminate Bruno's account of the movements of the earth and replied with a letter that Tocco published in his work comparing Bruno's Latin texts with the Italian. See Tocco 1889:313–35. Ingegno 1978:64 has pointed out that Schiaparelli's letter, rather than clarifying Bruno's reading of Copernicus, tended rather to add to the confusion by suggesting that, although Bruno certainly intended to supply an interpretation of Copernicus's astronomy, what he came up with was devoid of any serious astronomical basis.

13. Rita Sturlese's reading of Bruno's philosophy as a modified, immanentistic version of Ficino's neo-Platonism writes off with equal haste both Bruno's Copernicanism and his reference to Telesius. See Sturlese 1994.

considering the important point of Bruno's refusal of the traditional distinction between the *potentia absoluta* and the *potentia ordinata* of God, that is, his absolute power to create eternally in an infinite number of ways and his power to create in a moment of time the finite universal order in which we live.[14] Once the infinite universe is considered by Bruno as the space in which God's *potentia ordinata* and his *potentia absoluta* coincide, the infinite material substance itself becomes imbued with the total power of the divine intelligence. Bruno uses both neo-Platonic and Hermetic sources and vocabulary to express his sense of the divinity of his infinite universe; and any full account of his philosophy would have to consider his significant contribution to the lively renaissance discussion of metaphysical questions such as the nature of death, the problem of time, and the immortality of the soul. It is a mistake, however, to separate the consideration of such aspects of his thought from his natural philosophy. Precisely because Bruno sees the infinite material substance as rationally ordered by the divine intelligence, its infinite extension must necessarily assume a coherent physical ontology which he expresses as an infinite number of worlds.

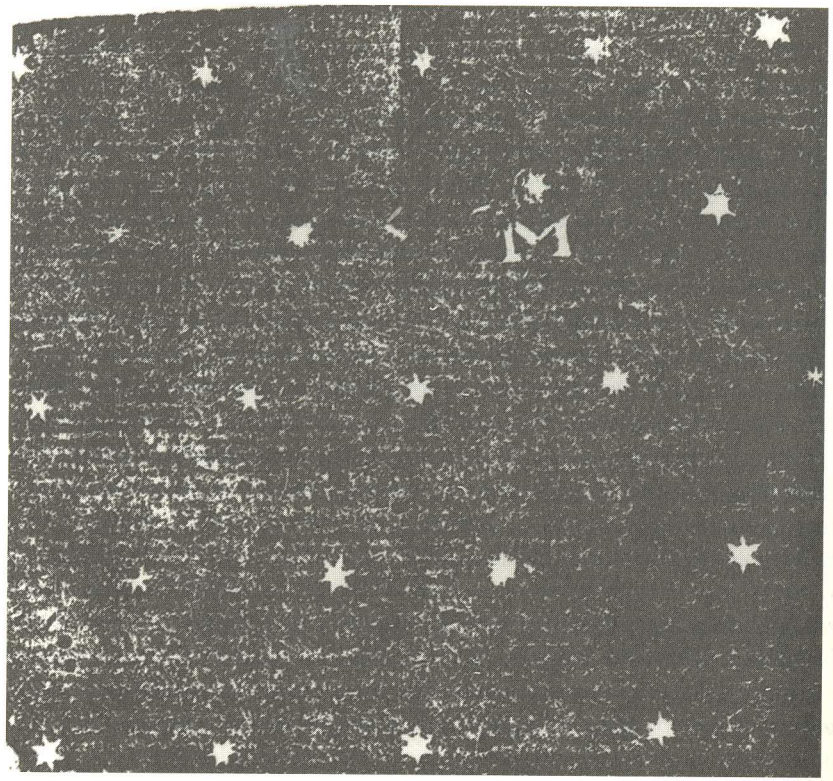
Bruno's infinite universe is conceived of as an intelligible cosmology in the modern scientific sense of the term. The laws controlling that intelligibility would be defined in the following century in increasingly refined and complex terms. Nevertheless, Bruno already proposes an unlimited cosmos in which motion assumes a basic ordered form, that of the movement of colder bodies around suns, mediated through the heliocentric astronomy of Copernicus. It is a cosmos in which that movement finds a theoretical physical foundation in the concept of an infinite and eternal opposition of contraries, mediated from Pythagoras through Cusanus. It is furthermore a cosmos in which one basic opposition, that of heat and cold mediated through Telesius, provides the explanation of planetary movement throughout the infinite whole. That Bruno's sense of the immensity of his infinite universe, as well as the complexity of the infinite vicissitudes to which it is necessarily subjected as the receptacle of God's absolute power, led him to develop a problematical attitude toward modern mathematics, and to the epistemological problem generally, is clear, and will be the subject of the following chapters. Nevertheless, the importance of his attempt to define the intelligibility of his infinite universe with its infinite number of worlds in terms of a new physics must not be ignored.

14. See in particular Granada 1994.

Bruno's attempt to apply the thermodynamic philosophy of Telesius to an infinite post-Copernican cosmology, foreign to Telesius himself, soon showed up its deficiencies. Telesius, as we have seen, failed to supply Bruno with the explanation of some planetary movements, such as that of the moon around the earth, which remained a puzzle in his system until the end. Although Bruno finally, in the *De immenso*, accepted that Copernicus had placed the moon on an epicycle revolving around earth, there was no real reason in Bruno's cosmology why that should be so. The magnetic philosophy of Gilbert, which would later be preferred by Galileo, offered a better explanation of the movements of bodies in the ether because it made them dependent on relative magnetic forces related to their mass. It is nevertheless of considerable importance that Gilbert himself mediated much of his cosmological reasoning through Bruno.

Johannes Kepler was far less enthusiastic than Gilbert about Bruno's cosmology. Kepler admits that the idea of a universal infinity populated by infinite worlds, which entirely destroys any idea of a privileged place for our own world within the universal whole, left him distressed and without any clear idea of his mental bearings: an attitude clearly shared by Tycho Brahe, who dismissed Bruno curtly as a Nolan *nullus*.[15] Kepler, however, discussed Bruno's cosmological speculations very seriously, even if he disagreed publicly with the most forward-looking and original aspect of his cosmology: his concept of universal infinity and the idea of an infinite number of solar systems within unbounded space. In chapter 21 of his *De stella serpentari* published in 1606, Kepler argued that our universe, which he thought of as post-Copernican and centered in the sun, fills the whole of space. He added more acutely that the fixed stars we see are related to the central sun and ought not to be considered suns of distant solar systems similar to ours. In his later *Dissertatio cum nuncio sidereo* of 1610, a public discussion with Galileo after the latter's discovery of the moons of Jupiter, Kepler refers frequently to Bruno's infinitism: a subject, he informs Galileo, much in discussion in the imperial court in Prague as a result of the enthusiastic adherence of the influential nobleman Giovan Matteo Wackher to a Brunian multisolar and infinite cosmology. Kepler had feared that the discovery by Galileo of previously unknown bodies revolving within the universe would confirm Bruno's theory of multiple solar systems; but he is comforted by the news that the discoveries are limited to the moons of Jupiter and therefore remain within our own and, for Kepler, unique solar system. Bruno's theory of

15. Kepler's extended reference to Bruno is discussed in Field 1988. See also Ricci 1990:69–76. For Tycho Brahe's disdain for Bruno's cosmology, see Sturlese 1985.



8. Diagram in Johannes Kepler, *Epitome astronomiae* (1618). Reproduced by permission of the Biblioteca Nazionale Centrale, Rome.

multiple solar systems within an infinite universe populated by infinite worlds will appear valid, writes Kepler to Galileo, only if and when future observers equipped with instruments of exceptional precision sight other suns similar to ours.[16]

In his later textbook of post-Copernican astronomy, *Epitome Astronomiae Copernicanae*, published between 1618 and 1621, Kepler conducts another discussion of universal infinity: a cosmological concept which is developed by an alter ego and illustrated in Figure 8. The text relating to this illustration runs:

> If nothing more certain than this were known about the fixed stars, it seems as though their domain were infinite: and this Sun of ours no more than one

16. On the discussion between Kepler and Galileo after the publication of Galileo's *Sidereus nuncius*, see Chevalley 1984.

> of the fixed stars, larger and brighter for us only because it is nearer than the fixed stars are; and so round any of the fixed stars there might be a world such as that round us; Or which comes to the same thing, among the innumerable places in this infinite collection of fixed stars, this our World with its Sun will be only one, in no way different from the other places near other individual fixed stars: As shown at M in the adjoining figure?

Kepler's reply to his alter ego is that it does not follow that because the centers of the stars do not all lie in one spherical surface then their distribution in space must be uniform throughout infinity—a uniformity that is not a part of Bruno's argument for infinity. Bruno does not claim that all solar systems are identical or that they lie at uniform distances one from the other. His argument, which is based on the concept of necessary plenitude, is that the bodies in infinite space must themselves be infinite in number although finite in kind. Furthermore, as, following Telesius, all celestial bodies are either hot or cold, luminous or opaque, throughout the infinite whole the cold and opaque bodies will necessarily circulate around the hot and luminous ones, in order to guarantee the infinite and eternal process of generation and corruption, that is, the infinite process of life. The homogeneity of Bruno's universe should therefore not be confused with the neo-Platonic, geometrical uniformity which Kepler considers a cosmological principle in pages which demonstrate above all a distaste for cosmological speculation about the shape of things beyond the limits of what can actually be observed.

Kepler's critique of Bruno's infinitism was not only directed against Whacker. In a letter of November 5, 1603, the astronomer Edward Bruce had written to him declaring his belief in infinite worlds which move through a space filled with an air similar to ours.[17] These cosmological premises were also accepted in England by the circle of scientists linked to the ninth earl of Northumberland, which included Thomas Harriot, who corresponded with Kepler. Harriot and his friends, however, developed their ideas on cosmological infinity through a critique of Kepler in an episode that is of particular interest because it involves one of the first documented English readings of Galileo's *Starry Messenger*.[18] It is not

17. Quoted in Ricci 1991:68. In the *Dissertatio cum Nuncio Sidereo* (see Kepler 1937–75, 6:289) Kepler associates Bruce with the infinite cosmology of Bruno, defining Bruce as a personal friend of both his own and Galileo's. On the same page, however, William Gilbert considers Kepler to have followed the ancient cosmologer Melissus in proposing a unique but infinite universe. See Ricci 1991:75.

18. For the details of this episode see Jacquot 1952:175–76, Gatti 1989:56, and Ricci 1990:76–79.

necessary here to repeat the details of that episode or to follow up the subsequent seventeenth-century cosmological discussion regarding the idea of universal infinity, which has already been well documented by Saverio Ricci.[19] What must be emphasized, however, is that Bruno's arguments about the infinity of the universe and the infinite number of worlds supplied, at the beginning of the seventeenth century, a point of innovation and discussion, both in England and abroad, which suggests once again that it is unwise to dismiss his contribution to the contemporary scientific debate as marginal or null.

Before leaving Bruno's cosmological speculation, a word needs to be said about his radically eclectic method of procedure. Bruno was no observational astronomer, and his cosmological data derive largely, in humanistic terms, from his reading.[20] If he nevertheless achieves at times startlingly original results, it is because of the width of his frame of reference added to the coherent and independent choices of what to discard and what to use. Bruno's cosmology depends on sources extending back to the ancients such as Pythagoras and Lucretius, through the scholastic debates of the Middle Ages, by way of the fifteenth-century Cusanus to the *novatores* such as Copernicus, Telesius, and Tycho Brahe. The system of natural philosophy which Bruno created from these sources, although often praised for its audacity, is equally often condemned as being shaky and ramshackle. On the contrary, it possessed a remarkable internal coherence and was one of the first modern cosmologies to attempt an explanation of the movements of the worlds through space which could be applied uniformly to an infinite number of worlds in movement throughout an infinite ether.

Bruno's use of the thermodynamic principle as the key to the universal movement of the worlds was only partially successful. Gilbert's magnetic explanation was better, as Galileo would soon point out. But Gilbert clearly had read Bruno. In the context of the post-Copernican search for a physical, explanatory principle regulating the movements of the worlds in space, it is thus possible to trace a line of development from Bruno's universal thermodynamic principle through Gilbert's magnetic philosophy leading to the gravitational laws of Newton.[21] Bruno himself might have been uneasy at the idea that the movement of bodies through space could be expressed by a mathematical law, a question on which Gilbert

19. Ricci 1990:131–238.

20. For the continuing importance of a humanistic methodology even among the most advanced of the new scientists of the period, see Gatti 1993:5–9.

21. On this subject, see also Mendoza 1995.

too was hesitant and uncertain. Nevertheless, it is important to recognize that Bruno was the first to react to the collapse of the Aristotelian cosmology and physics with the realization that it had become necessary to supply not only new measurements and mathematical calculations but also, and perhaps above all, explanations of the movements of an infinite number of worlds which would be valid throughout a universe of unified space.