PART II

Concrete Examples To Explain the Interpretive Nature of the Scientific Theories of Natural Science

Chapter I

Reflections on the Origin of Modern Physics: 16th and 17th Centuries: From Copernicus to Newton

In what follows I hope to discuss ideas of Ptolemy, Copernicus, Brahe, Kepler, Galileo, and Newton; in each case only very few observations can be made; yet I hope that what will be said will be adequate to explain what I have in mind: to show that the scientific *praxis* as a whole is inherently hermeneutical, and the same is true for all its constitutive aspects.[1]

About 150 A.D. Ptolemy published his *Megale Syntaxis tes Astronomias*, better known under its Arabic name, the *Almagest*. This became the standard text, on the basis of which in astronomy all observations, measurements, and calculations concerning the movements of the planets and the stars were made. Over the centuries minor changes were proposed, but substantially the work was maintained in its original form. For many centuries all observed phenomena were thus projected upon the framework of meaning articulated by Ptolemy. In other words, the results of all observations were interpreted on the basis of the prejudgments, which are inherent in Ptolemy's geocentric theory.

Fourteen hundred years later, in 1543 to be exact, Copernicus published his *De Revolutionibus Orbium Celestium*, in which he returned from a geocentric conception of the universe introduced by Heracleides (fourth century B.C.), to the heliocentric conception first introduced by Aristarchos (310-230 B.C.). Copernicus showed his work to Pope Clemens VII who encouraged Copernicus to publish the work in book form.[2]

Once it was published, Copernicus's *De Revolutionibus* did not receive an enthusiastic reception; in almost all countries there were quite a number of scholars who objected to the new ideas, either on religious and biblical grounds, or because of strictly scientific considerations. Tycho Brahe was one of the outspoken objectors.

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[1] Cf. *Ideas*, vol. 1, pp. 100–114.

[2] Cf. W.C. Dampier, *A History of Science in its Relations with Philosophy and Religion* (Cambridge: Cambridge University Press, 1971), pp. 111–12. The material discussed in this chapter has been presented during a conference held at Stony Brook and this paper was later published in a somewhat changed form under the title, "On the Hermeneutical Nature of Modern Natural Science," in *Man and World*, 30 (1997), pp. 299–313.

Brahe (1546-1601) was a well-trained and widely known astronomer in Denmark. When he was thirty years old he received from King Frederick of Denmark a small island, called Hven, located very close to Copenhagen. In addition he received the funds needed to build a castle-like observatory, Uraniborg, in which he later would work with his collaborators until 1597 and devote himself to scientific observations with the help of the finest instruments (armillaries, quadrants, sextants, torquetums, etc.), many of which were built according to his own specifications and instructions. Over a period of some fifteen years Brahe produced lunar and solar tables much more accurate than the ones available at his time, a catalogue of one thousand fixed stars with carefully measured values of longitude and latitude, tables for atmospheric refraction, and so on. In addition, he was able to improve several astronomical constants and to discover two new inequalities in the motion of the moon. He also was able to show that comets are not atmospheric phenomena, as most people of his time had assumed. He was particularly proud of his research concerning his new lunar theory, and above all, the development of a new geocentric picture of the world that contained all the important ideas of the systems of both Ptolemy and Copernicus, but was able to avoid their shortcomings.[3]

Let us now return to Brahe's criticism of the work of Copernicus. This criticism was based mainly on religious and biblical grounds; in this Tycho was influenced by Luther and Melanchton, who had stated that the views held by Copernicus were in clear contradiction with certain passages of Scriptures.[4] In addition, Brahe was also convinced that in astronomy one must not begin with a large-scale theory in order then, from that perspective, to derive the laws of nature; rather a good astronomer derives the laws of nature from the data secured by careful scientific examination. Yet in this point Brahe strongly disagreed with Ramus, who held that scientists should start totally independently of any theoretical speculation or theory; Tycho was convinced that scientific research without any hypothesis is simply impossible, whereas hypotheses can be formulated meaningfully only on the basis of some theoretical framework.[5]

Yet Brahe rejected the theory of Copernicus also on other grounds. First in his view it is difficult to conceive of the "heavy and sluggish" earth moving through space. Secondly, there is the immensity of the distance which, under that assumption, one would have to assume between the orbit of Saturn and the fixed stars. Thirdly, if the earth were to circle around the sun, and also

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[3] E.J. Dijksterhuis, *The Mechanization of the World Picture* (Princeton: Princeton University Press, 1986), pp. 300–03.
[4] Victor E. Thoren, *The Lord of Uraniborg. A Biography of Tycho Brahe* (Cambridge: Cambridge University Press, 1990), p. 276.
[5] Ibid., pp. 33–35.

to rotate around its own axis, a stone falling from a very higher tower would fall far away from the base of the tower. Fourthly, it is difficult to understand how one can assume a triple motion of the earth (around its axis, around the sun, and a "conical" motion of its axis to explain why the axis always points to the same point of the celestial sphere). Brahe also thought that in Copernicus's theory a cannonball shot from east to west would not fly as far as a similar cannonball shot from the same cannon from west to east. Finally, Brahe held that there is a disproportion between the fact that the fixed stars, in contradistinction to the planets and the moon, appear as mere luminous points, and not as discs, on the one hand, and the apparent diameters of the stars, on the other. Contrary to what Tycho knew about these diameters, they would have to be "astronomically" large.[6]

Yet, on the other hand, Brahe could not accept the theory of the *Almagest*, either. This was the reason why he began to look for a doubly eccentric system. I shall return to this issue shortly.

In 1597 the relationship between the King and Tycho had deteriorated to the point where the King refused to pay for any further expenses. Tycho had to dismiss his entire research crew, left Denmark, and in exile traveled around Europe with the aim of finding a new patron, willing to support further research. Finally in 1598 he found a patron in the Emperor of Prague for whom he worked until the end of his life in 1601.[7]

In 1600 Kepler joined Tycho in Prague "to supervise Tycho's publications," as Kepler expressed it in a letter.[8] Their encounter led to fruitful work during the last years of Tycho's life.

Yet it should be noted that when Kepler met Brahe, Kepler was already well-known through his book on astronomy, usually referred to with the title *Mysterium Cosmosgraphicum*, published in 1596. The content of this innovative book was also known to Brahe. In his work Kepler had explained that he accepted the system of Copernicus because (as he himself wrote) "of its superior mathematical simplicity and harmony." Being a distinguished and even enthusiastic believer in mathematics, and also deeply convinced of the Pythagorean and Platonic notion that numbers are at the root of all things, Kepler suggested that God had created the world in accordance with the principle of perfect numbers, so that the underlying mathematical harmony, which he called the music of the spheres, is the real cause of the planetary motions, and this harmony can be brought to light by careful study of the

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[6] J.L.E. Dryer, *A History of Astronomy from Thales to Kepler* (New York: Dover Publications, 1953), pp. 360–61.
[7] Cf. Thoren, pp. 370ff.
[8] Ibid., p. 439.

observed phenomena made available by the many observations of the planetary system over the centuries. In other words, in his first work it is abundantly clear that to explain the regularity discovered by observation, Kepler never appealed to a scientific, mechanical theory, but limited himself rather to philosophical, theological, and mystical speculations. As far as philosophical ideas are concerned they were derived from either Pythagorean or Platonic sources, or as far as the theory of motion is concerned from Aristotle.[9]

Another idea that gave Kepler great pleasure was the inspiration he received in 1595, namely that the fact that there are six planets in his view must be connected with the fact that there are precisely five regular polyhedra, and that there must be a correlation between their distances from the sun, on the one hand, and the radii of their spheres that can be ascribed to them and inscribed in these polyhedra. Thus if a cube is inscribed in the sphere containing the orbit of Saturn, then the sphere of Jupiter will just fit within this cube. If then again a tetrahedron be inscribed in the sphere of Jupiter, the sphere of Mars will fit within the tetrahedron, and so for the other regular solids and the six planets. Later it appeared that the relation referred to is true only by rough approximation. Furthermore, when later new planets were discovered, the basis for Kepler's theory was destroyed altogether.[10]

Finally, there is Kepler's idea that the planetary system is an image of the divine Trinity, in the sense that the Sun resembles the Father, the fixed stars the Son, and the ether the Holy Spirit, and that this image can be taken to be a confirmation for Copernicus's theory. These and similar examples show that during that period of his life in Kepler's work one does not yet find a scientific, i.e., mechanical, explanation of the regularity in the planetary system; rather Kepler was guided here by ideas that ultimately would come from his theological, mystical, and mathematical convictions.[11]

It is thus perfectly clear that Kepler in his description and explanation projected the observed phenomena upon frameworks of meaning, that were developed totally independently of his own observations. With respect to his observations, he looked at all phenomena and data from the perspective of Copernicus's heliocentric theory, whereas in explanations the observed phenomena were projected on a framework of meaning determined by Scriptures, theology, and Pythagorean and Platonic philosophical ideas. In other words, his work, too, is hermeneutic through and through, and rather arbitrary at

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[9] Dijksterhuis, pp. 303ff.
[10] Dampier, p. 128; cf. Dijksterhuis, pp. 303–04.
[11] Dryer, pp. 373–74.

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