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THE LATE MEDIEVAL ASTROLOGICAL SCHOOL AT CRACOW AND THE COPERNICAN SYSTEM

All students of the history of Polish science in the Middle Ages and early modern times owe the Birkenmajers, father (Ludwik Antoni, 1855—1929) and son (Aleksander, 1891—1967) a great debt for their numerous and valuable works on the two greatest names of Polish and indeed of European science: Witelo in the thirteenth century, and Copernicus in the sixteenth century[1]. Naturally a number of satellite figures of scientists surrounding or preparing the work of these two giants were also studied and made better known by our two worthy historians, who shed light at the same time upon the medieval and early modern scientific tradition in Poland. The University of Cracow, in particular, founded by Casimir the Great in 1364 and reorganized on a more permanent basis by Władysław Jagiełło in 1400 received the greatest attention for the late medieval period, especially from Aleksander Birkenmajer[2]. The evidence is unquestionable that in the fifteenth century in the new University of Cracow at which Copernicus received his early scientific training, interest in astronomy, and necessarily also in astrology, dominated by far the scientific life of masters and students.

In 1959, a group of Polish historians drew up a comprehensive program for a general history of astronomy in Poland, with Aleksander Birkenmajer being assigned the lion's share in coverage of the medieval period and up to the time of Copernicus and his immediate successors[3]. Aleksander died before the program's fulfilment. We are fortunate, nevertheless, thanks to the generosity of the Polish Academy of Sciences, to possess a posthumous collection of Aleksander Birkenmajer's works,

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[1] The bibliography of works by Ludwik Antoni Birkenmajer was published in *Wiadomości Matematyczne*, XXXIV (1932), pp. 66—73 (see *Studia Copernicana*, Vol. IV, 1972, p. 485, n. 3, hereafter referred to as *Stud. Cop.*, IV). Aleksander's own bibliography was included in A. Birkenmajer, *Etudes d'histoire des sciences et de la philosophie du moyen âge*, Wrocław, 1970 (*Studia Copernicana*, Vol. I, hereafter referred to as *Stud. Cop.*, I).

[2] *Stud. Cop.*, IV, pp. 3—32, 53—69, 437—559.

[3] *Ibid.*, pp. 33—52.

presented in French translation for wider diffusion[4]. Another posthumous collection of earlier works by Birkenmajer, ranging over the broader field of medieval science and learning, was also published under the auspices of the Polish Academy of Sciences[5], translated into French, and editorially handled in the same masterful way as the previously mentioned one. Both volumes made widely accessible these capital studies on European and Polish science of the Middle Ages which until now had not received all the consideration they deserved. For these ground-breaking studies of Aleksander Birkenmajer constitute the most informed and the most accurate picture of medieval astronomy in Poland and of some choice sectors of European medieval science as well, such as the studies on Witelo and on Richard of Fournival.

In the biography and intellectual history of Copernicus, we are reminded by Birkenmajer that the "father" of modern astronomy received his first scientific education at the University of Cracow between the years 1491 and 1495[6]. The fame and attraction of this university reached its height in the middle and last part of the fifteenth century after it had been reorganized by King Władysław Jagiełło and his wife Jadwiga. With all credit given to the abundant factual information supplied by Birkenmajer on the intellectual life and the learning institutions of Cracow and Poland in general at the time and as a result of this reorganization, one finds himself wishing that Birkenmajer would have found time and opportunity to scrutinize in greater detail the probable relations of Władysław's foundation with the actual situation at the contemporary nearby Universities of Prague, Leipzig, and Erfurt. The suggestion appears quite inescapable that the predominance of astronomical-astrological interests at Cracow might have been but an emulation and a continuation of similar inclinations among the members of these universities, as a great manuscript production of this type at these centers attests[7].

Birkenmajer used several approaches to describe the foundation of a chair of astronomy at Cracow University by Stobner shortly after 1400[8]. Although closely

[4] *Ibid.*

[5] *Stud. Cop.*, I.

[6] *Stud. Cop.*, IV, pp. 563–578, especially 563–567, and pp. 483–495, esp. 488–493.

[7] A. Birkenmajer (*Stud. Cop.*, IV, pp. 437–468) notes that many Silesians prior to the foundation of Prague University in 1348 would attend the University of Paris and bring back home both knowledge and manuscripts in astronomy-astrology (pp. 454–455). At the University of Erfurt, founded in 1392, and at that of Leipzig, founded in 1409, a similar astrological orientation among masters and students can equally be verified from a study of their manuscript production. Elements for this study may be gathered from E. Zinner, *Verzeichnis der astronomischen Handschriften des deutschen Kulturgebietes*, 1925.

[8] *Stud. Cop.*, IV, p. 5. *Idem*, pp. 455–456. *Idem*, p. 484 and p. 456, n. 62. Birkenmajer expresses the conviction that Mikołaj Stobner rather than Jan Stobner is the founder of this chair, on the grounds that a Mikołaj Stobner is mentioned in municipal documents of Cracow as owning a house in 1368/1369 on Jewish Square (plac Żydowski), hence in the proximity of the University. Yet, this Mikołaj, presumably a respected burgher in 1368 would have been pretty old at the time

related in time with Władysław's reorganization, the event had some more tha plausible connection with the exodus from Prague of non-Czech masters and students under the emergence of hussitism[9], and possibly also with the foundation of a university at Leipzig in 1409. The Stobner chair in which, according to Birkenmajer[10], astronomy and mathematics were taught, does not seem to have attracted any notable master before Marcin Król occupied it shortly in 1445[11], if indeed we may assume from the works he published during the time of his teaching at Cracow[12] that he was occupying the Stobnerian chair[13]. The best known graduates were seen to expatriate themselves, either to seek profitable employment as astrologers at the courts of kings, emperors, bishops and popes,[14] or to further their scientific training at northern Italian universities, especially Bologna and Padua. A number of these Cracow expatriates occupied in succession the chair of astrology at the University of Bologna[15], while pursuing the study of medicine or law. The teaching of astrology

of the Stobner foundation some forty years later; besides, is the ownership of a house near the university, without any further indication that this man had any connection with the studies at Cracow-a sufficiently positive indication of his interest in the new university? On the contrary, the other Stobner was a graduate of the University of Prague in 1379, which makes him quite a bit younger than the burgher Mikołaj of 1368, and definitely associated with studies in the Arts. The identification of Jan as the founder of this chair becomes all the more probable from an incidental remark included by Birkenmajer himself in his general outline of the history of astronomy in Poland (*Stud. Cop.* IV, p. 39) where he speaks of the "importation" of astronomical manuscripts from Prague.

[9] Birkenmajer does not mention any such connection in his various treatments of the university life in Poland in the early fifteenth century, except for this brief mention of importation of manuscripts from Prague, mentioned in note 8 above. Yet the foundation of a university at Leipzig in 1409, and at Erfurt in 1392 in German territory were not without some direct link with the emergence of Bohemian nationalism in Prague at the turn of the fourteenth and fifteenth century.

[10] *Stud. Cop.*, IV, p. 5. If this chair's program was in any way influenced by the curriculum of the similar chair at the University of Bologna in 1405, then mathematics, including the *Algorismus* and Euclid's *Elements* were indispensable in the study of astrology.

[11] *Stud. Cop.*, IV, pp. 5, 456–457, 469–470, 484. Birkenmajer does not know exactly when Król established the new chair bearing his name and exclusively dedicated to the teaching of astrology, but the most probable time of its establishment was after Król's death, or around 1460. Hence the activity of Król himself in 1445, and of his followers such as Grzymała, Gaszowiec, Marcin Bylica, Wojciech of Opatów, the most famous astrologers and wandering scholars of the 1440s and 1450s must be deemed as resulting essentially from the teaching imparted at Cracow through the earlier "astronomical" chair of Stobner.

[12] *Stud. Cop.*, IV, p. 5. These works are: *Algorismus minutiarum*, *Tractatus proportionum*, and *Geometria practica*.

[13] After this article had been finished, two recent articles on the early history of this chair by G. Rosińska came to my attention: "Sandivogius de Czechel et l'École Astronomique de Cracovie vers 1430", *Organon*, 9 (1973), pp. 217–229, and "Une Table astronomique de Laurent de Racibórz: le commentaire qui l'accompagne", *Mediaevalia Philosophica Polonorum*, 19 (1974), pp. 141–147.

[14] *Stud. Cop.*, IV, pp. 440, 471, 474.

[15] *Ibid.*, pp. 5–7, 457–458, 470–473, 485–486.

at the medical faculty of Bologna was of old standing[16]. In the year 1405 a new statute enacted at the University of Medicine and Arts prescribed a four year course of study in astrology, accompanied by a detailed list of the books to be statutorily read by the candidates in medicine[17]. It is natural, therefore, to conclude from their early success in Bologna, that the newcomers from Cracow offered an impressive display of their astrological competence on arrival. This success, in turn, must be deemed a sure indication of the nature of their training under the Stobnerian professors of "astronomy" in Cracow[18].

Some time after 1450, but more probably around 1459, a new chair dedicated to the teaching of astrology was established at the University of Cracow by a clause in the will of Marcin Król[19]. The incumbent at this chair was required to expound the following basic astrological authorities: Ptolemy's *Quadripartitum* (or *Tetra-*

[16] Mauro Sarti, *De claris Archigymnasii Bononiensis Professoribus a saec. XI usque ad saec. XIV*, Bologna, 1769–1772, Vol. I, pp. 436–437, 480 (about Boninsegna, 1298), 485–495. These lectures on astrology were usually given by younger faculty or even students, in preparation and anticipation of higher appointment to medical chairs. In the Parisian Roll of Artists of the Norman Nation for 1379, we find the mention of a John Durand, cleric of the diocese of Rouen, master of arts and second year student in medicine, reading astrology at Paris by order of the King (Denifle-Châtelain, *Chartularium*, Vol. III, p. 265: "legenti Parisius astrologiam ex precepto domini Regis"). This must be King Charles V whose library, studied by L. Delisle, contained all the important works of the time in astrology, and who furthermore paid a handsome amount to Nicolas Oresme for the French translation of Ptolemy's *Quadripartitum*, a basic book of astrology in medieval curricula at Paris, Bologna, and Cracow, among others. (Cf. Bibliothèque Nationale, *La Librairie de Charles V*, Paris, 1968, p. 53, 119: the sum of 200 gold francs was paid to Oresme on May 21, 1372, for translation of works by Aristotle. On pp. 114–115, 198 is listed the Dauphin's, future Charles V, copy of "Ptolémée, *Quadripartitum*" translated into French by Nicolas Oresme around 1362–1363. No sum of money for the translation is mentioned here). The John Durand mentioned in 1379 is again listed in 1387 as a member of the faculty of medicine at Paris and personal physician of the Duke of Burgundy, a brother of Charles V. As to the books of astrology taught in Paris at that time, we may have a definite indication from an earlier document of the same *Chartularium* of the University of Paris (Auctarium, col. 225): in 1358 a petition presented by a Robert le Normand to be allowed to teach, on festive days, "the *Centiloquium* and the *Opus Quadripartitum* of Ptolemy" was favorably received by the English Nation, which simultaneously granted Albert of Saxony's request to teach the *Politics* of Aristotle on the same days. This was not the first time that the English Nation at the University of Paris took the lead in innovating with respect to the curriculum. Shortly after the granting of both Robert le Normand's and Albert's petitions, a general reform of the curriculum in Arts was enacted in 1366, prescribing for candidates to the Arts license the auditing of lectures on "some books on mathematics [*aliquos libros mathematicos audiverint*]". *Libri mathematici*, as a general expression at that time, included principally books on astrology.

[17] C. Malagola, *Statuti delle Università e dei Collegi dello Studio Bolognese*, Bologna, 1888, p. 276. See below, note 53.

[18] The study of astronomy, when recorded in medieval curricula, rarely included, if ever, the *Almagest* or the *Alfraganus*, but most of the time would include the *Sphere* of Sacrobosco, the *Theorica planetarum*, and above all the various astronomical tables with their *Canons*, which occupied the focus of all such studies. These tables were the one important bridge from astronomy to astrology.

[19] *Stud. Cop.*, IV, pp. 6, 457, 470–471, 474, 484–486.

biblos) and *Aphorisms* (pseudo-Ptolemaic *Centiloquium*), the works of Alchabitius (al-Qabisi) and those of Abumasar (Abu Ma'shar) in addition to some other astrological works[20]. This program is a close reflection of the astrological curriculum at the Faculty of Medicine at Bologna, where Marcin Król had studied medicine after 1445 and even taught astrology in 1448 – 1449. Król's own scientific production at Cracow in 1445 indicated a greater proportion of pure mathematics; but since this mathematical part was also an integral part of the program of astrological studies for future physicians at Bologna, we may have to conclude that Król's new activity at Cracow after his return from Italy (he taught medicine at Cracow) resulted in the broadening of the mathematical program of the Stobnerian chair to include a greater amount of astrology, and finally in the foundation, after his death, of an independent or complementary chair to secure a permanent basis for this new outlook. Thus both "astronomical" chairs at the University of Cracow combined in reproducing the full scope of astrological teaching at Bologna discovered by Król.

Król's posthumous foundation at the University of Cracow only stabilized an already existing situation, for which he seems to have been primarily responsible. Birkenmajer enumerates the followers of Król who together with him made the University of Cracow in the late fifteenth century the most celebrated center of astronomical studies in Eastern Europe[21]. All of them, without exception, are primarily astrologers like Król himself, at least as shown in their works. This great reputation of Cracow is well understood in Bonfinius' and Hartmann Schedel's praise of Cracow: "Cracovia astrologis referta est"[22].

With a greater than usual measure of indulgence for the medieval astronomers' passion for astrology[23], Birkenmajer has assembled substantial information on the studies and publications of the professors of astronomy and astrology in Cracow University in the late fifteenth and early sixteenth centuries. The basic facts are as a rule[24] clearly stated by him and their intellectual and sociological implications

[20] *Ibid.*, pp. 470.

[21] *Ibid.*, pp. 474, 483 ff.

[22] *Ibid.*, pp. 464, n. 86: "a conjectoribus et astrologis, quibus referta Cracovia est". See also pp. 479, 491.

[23] A. Birkenmajer, "Coup d'oeil sur l'histoire des sciences..." [in:] *Stud. Cop.*, IV, p. 9: "Ne nous scandalisons donc pas de cet amalgame d'astronomie et d'astrologie qui faisait alors la gloire de l'Université de Cracovie; les contemporains le regardaient avec de tout autres yeux". "Les Débuts de l'école astrologique de Cracovie," [in:] *Stud. Cop.*, IV, pp. 470–471: "Evidemment, aux yeux de l'homme moderne, l'Université fit là [Król's astrological foundation] une acquisition contestable. Mais l'historien ne doit pas mesurer les événements d'après les seuls critères de l'état actuel de la science..." Birkenmajer's brief and penetrating sketch of the relations of astronomy and astrology since antiquity in "Les Astronomes et les astrologues silésiens au moyen-âge", [in:] *Stud. Cop.*, IV, pp. 437–468 (especially pp. 437–440 very useful).

[24] Only exceptions may be found in Birkenmajer's frequent confusion of labels when he qualifies, for instance, the studies of Marcin Król as "astronomical" (*Stud. Cop.*, IV, p. 5, 457, and *passim*), or his slipping to expressions like "astrological superstition" (*ibid.*, p. 6), "this fallacious doctrine" (*ibid.*, p. 471).

squarely faced. Yet, to some extent Birkenmajer's account fails — as most accounts of medieval astronomy do — to provide a satisfactory perspective which would explain the universal prevalence of astrology over astronomy in medieval and early modern times other than through a commiserate ascription of a general intellectual weakness shared by nearly every thinker and scientist of pre-Copernican times. That Copernicus' revolutionary concept of the mobility of the earth, (as is suggested by Birkenmajer[25]) or even the entire heliocentric system by itself alone does not provide the ultimate answer to this historical and epistemological question would seem to be amply evidenced in the refusal of Copernicus' immediate successors in Cracow[26], as well as in European circles at large, either to adopt his heliocentric theory without reservation, or to abandon their astrological beliefs and practices[27].

The interpretative flaw in this particular point of the historiography of pre-Newtonian science resides in the common failure to perceive the proper function and respective position of astronomy and astrology among the ancients. We tend to think of these two disciplines as two separate views of the science of the heavens, somewhat opposed to one another, one being, by our standards, demonstrably false and empty, the other having for itself a true foundation in objective reality. It must be realized, however, that since Newton's universal gravitation theory has replaced for us the Aristotelian hierarchy of causes and influences tightly knit in a descending order from the heavens, astrology or the observation and correlation of the apparent effect of the heavenly bodies upon movements in the "sublunar" world has been severed from astronomy and left without foundation in the new scientific outlook. Gravitational attraction, substituted for an order of causation from celestial to terrestrial domains, now forms the proper cosmic context of our lives and bodily motions. This was the substitution that dealt astrology its death blow, allowing none of its ancient and famed rules derived from a totally different cosmological and epistemological system to find shelter within the Newtonian system of gravitation and its mathematical treatment. In the historical category of interpretation, however, we absolutely cannot transfer the new epistemology to the understanding of pre-Newtonian conditions of science. To do so would be tantamount to reintroducing a corpse into the creative process of ancient science, thereby creating the silly picture of a prolonged and keen interest in the observation of the skies and planets stimulated at all times before our days by a complex of dead organs. And yet we cannot dismiss either, under pain of reckless misrepresentation, the adherence of ancient scientists to astrology as an inseparable companion science to astronomy, still more as the proper and ultimate end of astronomy.

This statement stands on two premisses, each one based on solid, if little observed, historical foundation. The one is that "adherence to", or acceptance of astrology does not mean actual practice of astrology as an art or a craft or profession, a situation which is too readily assumed by modern readers when we speak of the astrological beliefs of the ancients. In our statement, only the "scientific" foundation of astrology need be understood, namely the Aristotelian cosmological system of an orderly and hierarchical physical universe in which physical causation is transmitted from the skies above, the realm of the "unmoved movers", down to the earth below the sphere of the moon. We have presented this theoretical view of "Aristotelian Metaphysics and Astrology" in a paper read at the American University of Beirut in 1959.

Secondly, astrology since ancient times and until Newton does not consist merely of the drawing of horoscopes and of almanacs for prognostications. This is only its visible, operative part as a craft. In its theoretical part, clearly established by Ptolemy's *Tetrabiblos* on peripatetic foundations, astrology encompassed all astronomical knowledge, but seen in the light of its applicability to men's and the earth's life cycles. Until Newton, Ptolemy's view was challenged very rarely on comparable "scientific" grounds (v.g. Oresme's incommensurability of celestial motions denying validity of conjunction theories) and very partially. Only the "unwarranted" deductions from its principles by bold practitioners were criticized when they ventured to extend their interpretations to the minutiae of daily life, or to the realm of free will. As H. Butterfield seems to have grasped firmly, it was the "downfall of Aristotle and Ptolemy" (*The Origins of Modern Science*, ch. 4) which ultimately removed the false foundations of ancient science, including, of course, astrology.

However indispensable, this note of caution does not require lengthy elaboration. It is enough, for the broad purpose, to recall the symbiosis achieved by Ptolemy between astronomy, astrology, and physics inherited from the whole of Greek tradition, but especially from Aristotle, and aiming in the humanistic age of the Stoics at the benefit of the total man, the knower and the living participant in the cosmic process which it was his goal to interpret and adjust to. Astronomy as the science of the motions of the heavenly bodies, and astrology as the science of celestial influences deriving from such motions were combined by Ptolemy as two integral components of one single science of the heavens and earth, absorbing in the process

[25] Cf. "Les Astronomes et les astrologues silésiens...", pp. 437—438: "Oeuvre du XVIIe s., le déclin définitif du système géocentrique de l'Univers a privé la Terre, une fois pour toutes, de la situation privilégiée qu'elle occupait dans le Cosmos. La conséquence directe de ce fait fut la ruine des bases pseudo-scientifiques sur lesquelles s'appuyaient les croyances et les spéculations des anciens astrologues".

[26] Birkenmajer has himself noted this point in treating of the attitude of Copernicus' contemporaries and successors in "L'Audience de Copernic au XVIe siècle", [in:] *Stud. Cop.*, IV, pp. 717—781. In this connection, the entire volume of *Studia Copernicana* III deals with the reception of the Copernican system in various countries.

[27] The point is brought into sharp focus in the heated reaction of Birkenmajer to H. Butterfield's contention that the real scientific revolution of modern times was to come more than a century after Copernicus. A. Birkenmajer, "Les Eléments traditionnels et nouveaux dans la cosmologie de Nicolas Copernic", [in:] *Stud. Cop.*, IV, pp. 647—658, and H. Butterfield, *The Origins of Modern Science*, New York, 1953.

the entire study of nature or physics[28]. Both branches were utterly mathematical in the eyes of Ptolemy[29]. His scientific writings included a major work for each branch of that one science, the *Almagest* in astronomy and the *Tetrabiblos* (or *Opus Quadripartitum*) in astrology.

A third work of an exclusively astrological nature, although dealing at length with planetary motions, fixed stars, eclipses of sun and moon, comets, meteorology, medicine etc. was also ascribed to Ptolemy by the combined Arabian, Greek and Latin traditions of the Middle Ages, under the title of *Karpos* in Greek, *Tamara* in Arabic and diversely as *Fructus*, *Centiloquium*, *(100) Aphorisms* in Latin. Through a current research project on the character and fate of this pseudo-Ptolemaic work it has become clear that the entire work, propositions and commentary alike, has no earlier textual or literary tradition prior to the work of the well known Arab mathematician and astrologer Ahmad ibn Yūsuf ibn Ibrāhīm (+ ca. 912), the historian of the Tulunid dynasty of Egypt (A. D. 868–904) and author of several mathematical works translated into Latin such as the *De proportione et proportionalitate*. The work culled from Ptolemaic, Hermetic, and Sassanian sources, was put together by him and passed off on the authority of Ptolemy[30]. As a literary and scientific

[28] The universally accepted axiom, uncontroverted from the time of Ptolemy through the Arabian phase of Greek astronomy and until later than Copernicus' time, to the effect that "the science of the heavens includes two major branches, one on the motions of the heavenly bodies, the other on the influences they exert upon the motions of the sublunar world", was not merely an accidental and unnecessary merging of two parallel traditions, the one scientific, the other religious or superstitious, as is too frequently stated, but a conscious, deliberate statement on the epistemological structure of man's knowledge of the starry world. It was clearly affirmed to be so by Ptolemy in the frontispiece of his *Tetrabiblos*, elaborately emphasized in the lengthy first book of Abu Ma'shar's *Great Introduction to Astronomy*, the standard work of medieval Arabic, Latin, and Greek astrology; it was culled from Abu Ma'shar by Albertus Magnus, who made it the backbone of his defense of astronomy and astrology in his *Speculum astronomiae*. Another Arab astronomer much admired by medieval Latin astronomers, and who himself practiced both branches of the science, Thabit ibn Qurra, claimed Aristotle as the champion of this epistemological view in the prologue to his *De ymaginibus*, translated twice into Latin in the early twelfth century (by Adelard of Bath as *Liber prestigiorum Thebidis* and by John of Seville as the *Liber de ymaginibus*).

[29] The titles of *Almagest* and *Opus quadripartitum* by which Ptolemy's two principal works were known to medieval astronomers came from the Arabs, and through them to the medieval Latin world. Their respective Greek titles were: *Mathematikes syntaxeos biblia* ιγ, and *Mathematike tetrabiblos syntaxis*.

[30] No Greek manuscript of this text is anterior to the fourteenth century. In her 1941 edition of the Greek text of the *Karpos* [*Centiloquium*] (without commentary), rev. ed. Berlin, 1961, Aemilia Boer contends that some trace of Verbum 51 may be detected in Proclus, but she seems to miss the point. In the passage in question, Proclus draws from Egyptian sources (Petosiris and Zoroaster in the Hermetic tradition) and noting some slight discrepancy with Ptolemaic true doctrines, merely comments: "and Ptolemy does not disagree". This allusion in no way can be construed as a citation from the *Karpos*, but rather points to the Hermetic source of the later concoction by Ahmad ibn Yūsuf. Similarly, Boer's statement that the *Centiloquium* was known to the seventh century Syriac author Severus Sebokht results from a misreading of an article by F. Nau in *Revue de l'Orient Chrétien* quoted by her. Nau makes it perfectly clear that the citation of the *Centiloquium* in Sebokht appears in a passage interpolated by Bar Hebraeus in the thirteenth century.

fraud, it had relatively little success in the Arabic scientific tradition[31] if we except its later fortune in Persian after it was translated and commented upon anew by Al-Tūsī in late thirteenth century[32]. Neither was it very popular among the Byzantines who tended to discard the Arabian commentary[33] and transmit (after its translation from the Arabic) the text of the 100 propositions alone believed to be genuinely Ptolemaic. But among the medieval Latin astronomers and astrologers (and physicians) the *Centiloquium* became a fundamental work of astrological science, ranked on par with, and frequently above, the genuine *Quadripartitum* for its practical use. To date, a list of more than 160 manuscript copies of the Latin *Centiloquium* has been compiled from collections in European and American libraries, and some fifteen printed editions of the fifteenth and sixteenth centuries have been identified. These manuscript copies reveal the existence of five or six Latin translations from the Arabic during the twelfth and thirteenth centuries, with additional translations from the "Greek" text[34] and new commentaries produced in the fourteenth and fifteenth centuries till late into the Renaissance period. Even in the midst of the scientific revolution at the time of Descartes it was translated into French around 1650 by a Royal Professor of Mathematics in Paris[35]. In short, the Latin Middle Ages made the extraordinary fortune of this Arab forgery in the name of Ptolemy and Greek science.

The *Centiloquium* of Ptolemy was part of the curriculum on astrology at Paris in 1358, at Bologna in 1405[36], and at Cracow about 1450. This famous vademecum

[31] It is reported in the vaguest terms by Ibn al-Nadim in the *Fihrist* (B. Dodge's translation New York, 1970, Vol. II, p. 640) which is usually well informed on the works of Ptolemy translated into Arabic. Al-Nadim mentions no translator for this work, which he seems to know exclusively from the *Commentary* by Ahmad ibn Yūsuf. Ibn al-Qifti (p. 78) does not range this work under Ptolemy's rubric but under that of Ahmad ibn Yūsuf. Isolated quotations appear in an Arabic work of the eleventh century, the *Ghāyat al-hakīm* known in Latin as *Picatrix* (*cf.* H. Ritter, *Studien... Warburg*, XII ⟨1932⟩, pp. 323–325).

[32] The majority of items relating to the *Kitāb at-Tamara* in catalogues of Arabic manuscripts belong to this Persian commentary by Al-Tūsī. We have personally verified the situation in the Sulaymaniye, Nuruosmaniye, and Köprülü of Istanbul and the proportion is about five to one in favor of the text of Al-Tūsī.

[33] So did A. Boer in her critical edition of the Greek text. The Renaissance tradition, born of the fifteenth century translations of this text by George of Trebizond and by J. G. Pontano, bears the mark of this Greek attitude. It goes without saying that George of Trebizond as well as Pontano believed in the Ptolemaean authorship of at least the *Verba*. Outside of the circles influenced by the Italian (and Byzantine) renaissance of Greek, we find two other translations, or rather added commentaries, one by William of Aragon in the middle of the fourteenth century, and one by Conrad Heingarter, physician of the Duke of Berry c. 1450. Both reproduce the earlier Latin version with the commentary of the Arab author, to which they add their own original commentary.

[34] Pontano's version gives the impression of independence from the Arabic commentary and its earlier medieval Latin tradition; but his familiarity with the earlier Latin text of the commentary is obvious in some passages of his *De coelestibus rebus*.

[35] J. B. Morin, criticizing another recent French interpretation by Nicolas Bourdin.

[36] See Malagola, *op. cit.*, pp. 264 and 276 (note 53, below).

of astrologers was no doubt also utilized in other centers of university life where astronomy-astrology was specially favored, such as at Padua, Erfurt, Prague, Oxford, and Cambridge, as the even distribution of surviving manuscript copies at all these centers seems to attest[37]. In Eastern European university centers of the Middle Ages we find numerous surviving copies usually dated from about the time the universities were established there. Seven copies are preserved in the University Library at Leipzig, ten copies in the Amplonian collection at Erfurt, nine copies in the Jagiellonian Library at Cracow. In addition, five copies are preserved in Berlin, some of which were made in Erfurt[38]. The abiding popularity of the *Centiloquium* lends great

[37] The British Museum has eight copies of the various Latin versions, while we find in the Harleian collection a codex 5597 of the sixteenth century containing a Greek copy entitled *C. Ptolemei karpos sive Florilegium 100 capitum cum dedicationibus binis graecis ad Cardinalem Farnesium, per Ranusium Sanctorium Altamurium.* The various libraries at Cambridge University preserve seven copies of the Latin text; in Oxford Libraries, we find eleven copies. This compares with about fifteen copies at the Bibliothèque Nationale in Paris and fifteen at the Vatican Library.

[38] MS 805 of the Jagiellonian Library at Cracow, which contains a partial copy of the medical treatise *Mihi competit* of the physician and astrologer Thomas of Sarepte (*Stud. Cop.*, IV, p. 451, n. 46), also contains a text of the *Centiloquium.* Other dated or signed copies in the Jagiellonian Library are: MS 1839, dated A. D 1508, done under Maciej of Kraina (on him, see A. Birkenmajer, *Stud. Cop.*, IV, p. 745); MS 1859, dated A. D. 1411, on the eve of Christmas, done by a certain Wencesław whose full name we have been unable to decipher (fol. 205*v*); MS 1963, dated A. D. 1506, and MS 2703, dated A. D. 1453 (fol. 169*v*). A very interesting codex containing some twenty-five astronomical and astrological works written between the years 1443 and 1458 in Brunswick, Erfurt, and Padua by a magister Liudolf de Borchtorp, is now preserved at the Staatsbibliothek der Preussischer Kulturbesitz in Berlin-Dahlem. It is MS Latin, fol. 246 of the fourteenth century, unknown to E. Zinner's *Verzeichnis* and hence little studied by historians of medieval astronomy and astrology. It contains a copy of the *Centiloquium* at ff. 24–32, a treatise *De 48 ymaginibus caeli* at ff. 46–48. Cf. a work of similar title written at Cracow in late fifteenth century by Jan of Głogów in A. Birkenmajer, *Stud. Cop.*, IV, p. 477, the *Speculum Astronomiae* of Albertus Magnus at ff. 75–79, a copy of the *Turquetum* at ff. 81–82; cf. also A. Birkenmajer, "Le Torquetum de Marcin Bylica d'Olkusz à la lumière de la récente découverte du Torquetum de Nicolas de Cusa", [in:] *Stud. Cop.*, IV, pp. 537–540.

One of the few works not transcribed by Liudolf de Borchtorp in this Codex, but by a student of his named Henry of Brunswick, is a lecture entitled *Of the Measurement of the Earth and of the Heavenly Bodies* (*De mensuratione terre et corporum celestium*), and delivered at Erfurt in 1445: "in studio Erfordensi pro honorabili viro magistro ludolfo [margin: borchtorp] de brunswick anno domini 1445 incompleto..." This precious bit of information tells us that the teaching of astronomy went on at the University of Erfurt in the middle of the fifteenth century. It must be compared with A. Birkenmajer's statement (*Stud. Cop.*, IV, p. 5): "Aucune autre Université de l'Europe Centrale [other than Cracow] n'aurait pu se prévaloir, jusqu'à la fin du Moyen Age, d'une chaire analogue [Stobnerian chair]". Cf. *ibid.*, pp. 456, 484, 565. [Editor's note: Birkenmajer states merely that until the end of the Middle Ages no chair similar to the one founded by Stobner existed in the universities of Central Europe. This is different from stating that the teaching of astronomy was absent from the curriculum of those universities]. Incidentally, an extremely interesting study would be to trace the diffusion of astronomical and astrological manuscripts produced at that time in Cracow that eventually found their way into other European centers of learning. A beginning is indicated in A. Birkenmajer, *op. cit.*, pp. 493–495. A number of initial indications may be found in Zinner, *op. cit.*

importance, hitherto overlooked, to the epistemological and scientific preparation of the students of astronomy in the Latin Middle Ages. Copernicus himself, no doubt, was familiar with this particular text and others taught at the Marcin Król chair at Cracow in his student days[39], although neither the *Commentariolus* nor the *De revolutionibus* cite them.

Medieval users of the *Centiloquium* had become generally aware of the existence of several Latin versions as is made evident from the numerous manuscript copies carrying three parallel renderings of the first 39 Propositions and two renderings of Propositions 40 to 99, with a variety of four or five versions for the last Proposition on comets and shooting stars[40]. Furthermore, standard appendices supplementing the doctrines of duration of pregnancy, of critical days of a disease, and of comets are present in a large number of Latin copies, and the commentary was handed down in at least three different versions by the thirteenth century. So when George of Trebizond's and J. G. Pontano's new versions of the Propositions translated from the Greek appeared shortly after 1450, accompanied by fresh commentaries in which references to the contemporary situation in Italy replaced the lore of the Arabian commentator and forger, the popularity and influence of the *Centiloquium* was increased and reached still wider circles outside the universities[41]. But the reputation of this forgery, its uninterrupted transmission among astronomers, astrologers and physicians shows that it hardly ever was in need of a revival. In company with the genuine *Quadripartitum* of which it claimed to be a practical summary, the *Centiloquium* proferred numerous incentives for the observation and calculation of the movements of the planets, the daily position of stars and planets, of orbits (cyclical progression of ascendants and of *directiones* ⟨tasyir⟩)[42], the notations of eclipses, syzygies, seasons, weather conditions, comets and meteors, equinoctial times, and year's length. Logically enough, all such data had to be looked for in astronomical tables. Hence the enormous and continuous demand for "correct" astronomical tables on which to base valid astrological judgments constituted a potent stimulant to astronomical studies in late medieval times[43]. Two basic sets of such tables dominated

[39] *Stud. Cop.*, IV, pp. 565, 596–597.

[40] The triple version in these codices stops with Verbum 39 because the third version by Adelard of Bath, ends with Verbum 39 in all independent copies of his version (only two: Lyon 328, and London, BM Sloane 2030). Proposition 100 on the comets, independently from the frequently accompanying tract "Dixit Ptolemeus quod stelle cum caudis sunt 9" itself appearing in two different versions, was handled in a very cautious way by the various translators, some hesitating to translate technical Arabic terms which they left unmodified in their Latin rendering.

[41] Pontano, in fact, further incorporated the medieval Arabian commentary in several passages of his other important astrological work, the *De rebus coelestibus.*

[42] See note 52 below.

[43] *Stud. Cop.*, IV, p. 439: "Le déclin du Moyen Age est tout simplement le 'siècle d'or' de l'astrologie..." Further (p. 439 bottom), Birkenmajer writes: "Les astrologues continuent à profiter du travail des astronomes, utilisent en premier lieu les tables des mouvements des corps célestes établies par ces derniers..." This is all fine provided the causal relation is put in the reverse order,

the field at different periods: the *Toledan Tables* of az-Zarqāli (ca. 1070) based on *Al-Khwarizmian Tables* (ca. 825 in Baghdad) but adapted to the Hegira years and to a Western meridian reigned supreme till they were supplanted by the *Alfonsine Tables* in the fourteenth century. Neither of these sets, however, calculated on the basis of the Ptolemaic system and accompanied by canons explaining their function, were considered satisfactory for any length of time, owing to their discrepancy with actual observation of the real positions of heavenly bodies which was performed quite frequently as a distinctive feature of medieval Latin astronomy[44]. Yet, this truly scientific vein of medieval astronomy was principally valued and practiced for its applicability and usefulness at all levels of political and social activity in medieval society. This humanistic goal of the science of the stars spells out much more accurately, in our opinion, the source and nature of the collusion between astronomy and astrology in older times than the remark of Kepler's that the "foolish" daughter (astrology) nourished her "sensible" mother (astronomy) quite well[45]. In the sociological and cultural context of medieval society, astrology was the mother, or better still the taskmaster putting astronomy to work steadily for her.

Birkenmajer's enlightening information on the predominance of astrological interests in the study of astronomy at Cracow between 1450 and 1550 may now be brought together with the realization of the popularity and extensive use of astrological works, such as the *Centiloquium* among others, in the teaching of astronomy in medieval universities. The peculiar convergence of information suggests highly interesting hypotheses concerning the realistic context of Copernicus' early education in astronomical science at Cracow and brings us closer to the probable motives which led him early to abandon the traditional hypotheses of planetary theory in the Ptolemaic system. The convergence further throws light on the conditions still prevailing among astronomers at the time and immediately after the publication of the *De revolutionibus*, explaining to some degree the reasons for the long delay in the reception of his heliocentric hypothesis.

First, it is sometimes assumed that Copernicus began to cast doubt on the validity of the geocentric system of Ptolemy as early as his student days in Cracow (1491–1495)[46]. In so doing he would have been motivated according to Birkenmajer[47],

namely that the astronomers seldom worked for independent purpose, but rather for the benefit of the astrologers whose practical needs made up the effective demand for astronomical tables. Or better still, one might say that the workers in both fields are the same persons who indulge in astronomical observation and study for the sake of their astrological endeavors.

[44] *Cf.* paper on astronomical observations by John of Murs (Johannes de Muris) read by Prof. Guy Beaujouan at the XIVth International Congress of the History of Science, Tokyo, August 1974, *Proceedings* no. 2, Tokyo, 1975, pp. 27–30.

[45] J. Kepler, *Gesammelte Werke*, ed. M. Caspar, Munich, 1938–1959, Vol. I, p. 22; Vol. IV, p. 161; Vol. XVII, p. 211.

[46] Cf. A. Birkenmajer, *Stud. Cop.*, IV, pp. 569–597.

[47] *Ibid.*, pp. 600–601. Also, Butterfield, *op. cit.*, p. 20, suggests a number of other pos-

by the realization that the two traditional systems of cosmic arrangement, the philosophical one of Aristotle with its homocentric spheres and the mathematical one of Ptolemy introducing eccentrics and epicycles — both systems being taught at the same time although at different levels of the university curriculum — could not be accepted on account of intolerable inconsistencies. For Copernicus would have noticed that the philosophically more sophisticated and mathematically more advanced system of Ptolemy contained some glaring inconsistencies of method, as in the case of the equant[48], which contradicted the accepted axiom of perfectly circular motions. There were also inconsistencies with respect to observation; for example in the theory of the moon's epicycle, the theoretical positions deduced were actually contradicted by observation of the size of the moon at quadrature[49].

Such an explanation of Copernicus' earliest negative reaction to the traditional planetary hypotheses of Ptolemy would seem to us to read back into his student days too much of the critical acumen that grew along with his scientific development. Rather, granting with Birkenmajer the historical reality of the overwhelmingly astrological preoccupation of masters and students at the University of Cracow at the time of Copernicus' studies, one feels bound to look in that direction in the first place for an explanation of the early dissatisfaction of young Copernicus with the existing astronomical systems. At age twenty and conscientiously taking his courses on the science of the heavens taught by internationally famous astrologers, young Copernicus is more likely to have concentrated his attention on more obvious problems and contradictions or uncertainties of astronomical science, such as the inevitably present and constantly detected errors in current astronomical tables used by astrologers. Moreover, Copernicus himself seems to offer us a clue to his preoccupations at that period of his studies which has not been sufficiently emphasized by his biographers, naturally excessively influenced by the spectacle of the fully unfolded mental development. For instance, when he moved to Italy for the first time in the fall of 1496, ostensibly to study law by arrangement of his uncle bishop, but with the secret intention of continuing his astronomical studies[50] at the celebrated center of such studies in Bologna, Copernicus brought with him two astronomical works which he had bought in Cracow in or around 1493. They were the *Alfonsine Tables* and the *Tabulae directionum* of Regiomontanus[51]. There can be no doubt that Regio-

sible motives, among which could be reckoned the realization that Ptolemy was "cheating" with his addition of an "equant", or the keen perception by Copernicus' strong geometrical mind of the uselessness of a number of circles corresponding in each planetary orbit to the motion of the earth, or finally, the contemporary resurgence of neo-Platonic speculations about the "regal" position of the sun. But such factors are much more difficult to establish.

[48] Cf. A. Birkenmajer, *Stud. Cop.*, IV, p. 568, and Butterfield, *op. cit.*, p. 20.

[49] A. Birkenmajer, *op. cit.*, pp. 570, 603.

[50] *Ibid.*, pp. 592–593.

[51] *Ibid.*, p. 593, n. 8.

montanus' *Tables* had a directly and exclusively astrological significance[52]. On the other hand, the *Alfonsine Tables*, belonging to the stock and trade of the astrologers and used as a text in the courses on astrology at Bologna[53], were more than 200 years old at that particular time. Like its predecessor the *Toledan Tables* of az-Zarqāli, they had been the object of repeated attempts at correction, even in the more recent period at Cracow[54], and despite the general dissatisfaction thus displayed openly with them, they were still used by the astrologers after Copernicus' death, as for

52 *Ibid.*, p. 464: "...destinées à l'astrologie, les *Tables* de Regiomontanus avaient une base purement astronomique", and note 85: "Il y est question de la solution numérique de certains problèmes d'astronomie sphérique qui trouvent application aux calculs astrologiques". The astrological *directiones* dealt with by Regiomontanus correspond to the Arabic expression *tasyir*. The direction was the measure of the progression of the place of the great (and mean and minor) conjunctions of the superior planets in the Zodiac. They had as much to do with spherical astronomy as the concept and measurement of the Persian *World-Years*, of Cicero's and Plato's *Magnus Annus* and of the Indians' *Kalpas*. In the pseudo-Ptolemaic *Centiloquium* several rules of interpretation of the system of conjunctions of planets involved the careful notation of the present rate of the *tasyir* (*attacir* in the text) or "directiones". It was the accurate determination of this fabulous rate which was the object of Regiomontanus' *Tables of directions*. Nicolas Oresme, in attacking the astronomical fallacy of the conjunction theory, had stressed the incommensurability of the planetary motions, thereby withdrawing any astronomical foundation from the *directiones*, a full century before Regiomontanus' *Tables*. See E. Zinner, *Leben und Wirken des John. Müller von Königsberg genannt Regiomontanus*, Osnabrück, 1968, p. 71.

53 Malagola, *op. cit.*, prints the *Statute for the University of Medicine and Arts* enacted in 1405. The books to be read by the student in medicine include a category "in astrologia" (p. 276) to be taught in a sequence of four years. The prescribed books are the following:

1st year: Algorismi de minutis et integris
Primus Geometriae Euclidis cum commento Campani
Tabulae Alphonsi cum canonibus
Theorica planetarum
2nd year: Tractatus de sphera
Secundus geometriae Euclidis
Canones super tabulis de lineriis
Tractatus astrolabii Mes(sa)chale
3rd year: Alkabicius
Centiloquium Ptolemei cum commento haly
Tertius Geometriae (Euclidis)
Tractatus quadrantis
4th year: Quadripartitus totus (Ptolemy)
Liber de urina non visa
Dictio 3a Almagesti

The Alfonsine Tables and their *Canons* could not be more definitely identified with astrological studies and practice. In like manner the *Elements* of Euclid, the *Theorica planetarum*, the *Sphere* of Sacrobosco, and even the *Almagest* of Ptolemy, are also included in the astrological program of Bologna. That this program of studies, notwithstanding its apparently mathematical part, was really astrological is evident from the fact that it was designed for students of medicine, the vast majority of whom would utilize astrology, rather than astronomy or mathematics, in their practice.

54 *Stud. Cop.*, IV, p. 518, Tables of Grzymała.

example Leovitius, Hilary of Wiślica, G. Moleti, and Erasmus Reinhold[55]. Indeed, preference for the *Alfonsine Tables* over the early tables drawn from Copernicus' *De revolutionibus* became the ostensible motive of these later astrologers to disregard the new heliocentric hypothesis until Kepler would change the situation radically. At the time of Copernicus' studies in Cracow, right in the year when he bought a copy of Regiomontanus' *Tables* which he later brought with him to Italy, Jan of Głogów commented in his *Interpretatio Almanach*[56] on another astrological work of Regiomontanus, and later edited a second version of this commentary in 1499. In the meantime, the same Jan of Głogów in 1497 wrote *Canones Tabularum Directionum Johannis de Regiomonte*. It thus appears beyond doubt that the student Copernicus positively shared the interest of the Cracovian masters in astrology[57], and particularly their concern over the accuracy of the astronomical tables of King Alfonso and of Regiomontanus. In addition Copernicus as a student had acquired other books, as Birkenmajer reports[58]; four are mentioned by name which include, besides the two aforementioned sets of astronomical tables, the *Elements* of Euclid printed in 1482 and the *Praeclarissimus liber completus in iudiciis astrorum* of Abenragel (Ibn Abi ar-Rigial) printed in 1485. As was seen in the astrological curriculum prescribed at the University of Bologna[59], the *Elements* of Euclid was a must for a student who intended to take the courses in astrology at that University. As to Abenragel's *Liber completus*, there could hardly have been a more decidedly astrological encyclopedia available in convenient form at the time of Copernicus' studies. This enormous hodge podge of astrological lore from an Arab astrologer of Tunis had been made famous among the Latins thanks to its double translation done under the patronage of King Alfonso el Sabio around 1255, first into Spanish by Judah ben Moses ha-Kohen[60] and from Spanish into Latin by Egidius de Tebaldis and Peter de Regio. The Latin Abenragel traveled the same course as the *Alfonsine Tables*, both being integral components of a good astrologer's library in the late Middle Ages. Whatever direction the later scientific interest of Copernicus may have taken, in his student days at Cracow and immediately upon his arrival in Bologna where he began to associate with Domenico Maria Novara[61] in astronomical observa-

55 Cf. A. Birkenmajer, *op. cit.*, pp. 717–778 (Leovitius, pp. 767–768, G. Moleti, pp. 771–772, Reinhold, pp. 761–766, Hilary of Wiślica, pp. 754–760).

56 *Stud. Cop.*, IV, pp. 462, 476.

57 A. Birkenmajer inclines (*Stud. Cop.*, IV, p. 595, n. 14. and p. 597, n. 16) against plain evidence, in our opinion, to deny or belittle astrological influence on Copernicus.

58 *Ibid.*, p. 597, n. 18.

59 See note 53 above.

60 Recently edited by G. Hilty, *Aly aben Ragel: El Libro Conplido en los Iudizios de las Estrellas. Traductión hecha en la corte de Alfonso el Sabio.* Prologo de A. Steiger, La Real Academia Española, Madrid, 1954. Cf. G. Hilty, "El Libro Conplido en los Iudizios de la Estrellas", *Al-Andalus*, XX (1955), pp. 1–74; A. R. Nykl, "Libro Conplido en los Judizios de las Estrellas", *Speculum*, XXIX (1954), pp. 85–99.

61 *Stud. Cop.*, IV, p. 570. Cf. *ibid.*, pp. 40, 593, n. 10, 608.

tions, his main interest seems to have laid in the accuracy of astronomical tables seemingly unattainable until then, but which he probably was determined to achieve by renewed observation of the skies, as he did in Bologna, or by questioning, if necessary, the planetary theories behind the canons of existing tables. The transition from observation for the purpose of amending the existing tables, to the construction of new hypotheses of the planetary motions in order to obtain tables of positions more in accord with observations was certainly an open option that could have dawned early in the mind of Copernicus bent on curing the radical weaknesses of all previous tables. How early did he take the step from one method to the other, remains however a delicate point. Birkenmajer[62] would place the genesis of the heliocentric theory in the Paduan days during the second stay in Italy (1501—1503) and further considers the impact of the newly published *Epitome in Almagestum* of Peurbach and Regiomontanus in Venice 1496 to have been decisive. This is quite likely to have been the case since it is in this book that Copernicus seems to have for the first time been confronted with the general theory of the *Almagest* (not a vademecum to the astrologers at Cracow!) and stared at the grossly inadequate theory of the moon's epicycle, which he decided to verify at the first opportunity for observation which came on 9 March 1497. From then on it is reasonable to think that Copernicus became convinced that astronomical tables constructed along theories like the Ptolemaic one which allowed such a discrepancy between numerical calculation and the reality supplied by observation, could not be cured permanently. The hypotheses would have to be abandoned and new ones sought for. Nevertheless the later evolution of Copernicus' researches reveals two permanent drives: his determination to arrive at permanently correct tables of positions of the planets, and his unswerving attachment to the heliocentric theory from which he labored to deduct all its mathematical implications[63]. The first goal had been fundamentally accomplished when in 1535 he was asked by his friend Bernard Wapowski and acceded to his request to publish an almanac for the year 1536 presenting tables calculated on the basis of Copernicus' data obtained from his heliocentric system. Wapowski hoped to convince the public "how these tables would surpass all others by their accuracy"[64]. The second goal of Copernicus, pursued with admirable constancy and in solitude away from the academic circles, drew him into advanced speculation[65].

[62] *Ibid.*, pp. 571—572, contains a more explicit description of Copernicus' evolution at that period of his studies. P. 571 also suggests that the Cracow period as well as the Bolognese one were exclusively negative in the sense that Copernicus' doubts only increased toward the geocentric system until the crucial observation of 9 March 1497 at Bologna, which set him on a program of rereading the ancients to find alternatives to the Ptolemaic system.

[63] *Ibid.*, p. 571.

[64] *Ibid.*, p. 577.

[65] J. L. E. Dreyer, *A History of Astronomy from Thales to Kepler*, rev. ed., Dover Publications, 1953, p. 310.

The earliest readers of the *De revolutionibus* who drew from it their astronomical tables, like Hilary of Wiślica [66], and Erasmus Reinhold, author of the *Prussian Tables* of 1551[67], apparently did so with the expectation that Wapowski's argument on the superiority of the heliocentric tables would prove true, for they were nearly all practicing astrologers with the same predicament that tore Copernicus away from the reliance on the Ptolemaic system. Pretty soon, though, owing to the incompleteness of the mathematical and observational bases of the Copernican system as left by its discoverer, the astrologers were disappointed in their expectations and reverted to the good old *Alfonsine Tables*. Leovitius and G. Moleti, both astrologers writing in the 1560s stated that tables drawn from the *De revolutionibus* might seem better for the positions of the three superior planets (Saturn, Jupiter, and Mars), but that the *Alfonsine Tables* were more accurate and reliable for eclipses, and for the movements of the inferior planets (Venus, Mercury, and the Moon)[68]. Copernicus' heliocentric hypothesis, on the other hand, was hardly noticed and apparently never seriously considered by them. For many years to come after the publication of the *De revolutionibus* the vast majority of the students of the stars remain staunch astrologers, eager to obtain the best tools for their trade and hence willing to consider any new system of tables, however revolutionary, provided they are not caught in glaring opposition to observational evidence. In this the *De revolutionibus* disappointed them as stated by Leovitius and Moleti, and they left it aside. Even Tycho Brahe found the mathematical constructions of the *De revolutionibus* too detached from actual observation.

If we have allowed ourselves to consider for a moment the initial inspiration of Copernicus' to be born in a cultural and scientific milieu saturated with astrological preoccupations in relation to the use of correct astronomical tables, it was because the weight of external evidence bore heavily in that direction; the internal or direct evidence on the other hand is naturally much harder and more subtle for the outside observer to detect. Nevertheless the few indices we have pointed to, duly recorded but not properly pondered till now, deserve careful interpretation. For after all, if the end term of Copernicus' evolution stands in rather bright light, the determination of

[66] See note 55 above.

[67] *Ibid.*

[68] Cf. *ibid.*, pp. 771 on G. Moleti and 772—773 on Leovitius. One only has to recall the extreme importance in astronomical judgments of eclipses of sun and moon, of syzygies, and of Venus' and Mercury's movements, as shown in the *Centiloquium*, to realize the damaging effect upon astrologers of the weaknesses of the early heliocentric tables, as pointed out by these famous astrologers of Copernicus' time. [Editor's note: It must, however, be pointed out, that Moleti, among others, later changed his mind about the Copernican tables and used them to prepare his *Tabulae Gregorianae* (Venice, 1580). He explained his action by the fact that "the data in the Alfonsine Tables does not correspond to the celestial phenomena. And we would still have this difficult situation [i.e. the disagreement between the data and observations] were it not for Nicholas Copernicus, the Hercules of our times, who recognized the inequality of the motions and adjusted them according to his assumptions and computations" (fol. 6*v*).]

the beginning of the evolution will confer a realistic historical perspective to his achievement. The ultimate merit of Copernicus' handling of the astronomical aporia of his time lies in the constancy with which he developed his revolutionary hypothesis once he had got the intuition that in it rested the solution toward the correct astronomical tables he was looking for. Such persistence in a truly scientific orientation of a lifetime, whatever were the conditions of its coming to the fore, and despite the opposite pull of a scientific community steeped in the astrological tradition, reveals the ingredients of genius. Possibly, additional factors of an economic and social nature may have helped the great man's determination and success, but could not have replaced it. During his whole lifetime, once passed the brief interval of family misfortunes due to the loss of his father, Copernicus was freed from financial worries thanks to the protection and help offered by his uncle, Bishop Lukas Watzenrode who secured for him a canonry. To be able to indulge in the detached and independent pursuit of astronomical studies goaded by nothing else than the love of truth, and furthermore to contemplate with serenity a lifetime dedication to the realization of a single major idea, was not given to the ordinary astronomer--astrologer of Copernicus' times. Pressing financial needs of the scholar, relatively well satisfied in professions such as medicine or law, could ordinarily be met by the student in astronomy only if he were ready to follow the social aspect of his science deemed by his contemporaries to be beneficial in private and public life. Among emperors, princes, bishops and even popes the illusion that power and success could effectively be enhanced by the methods of astrological science[69] created a steady demand on the astronomer to become an astrologer. The more "scientifically" equipped the astrologer showed himself to be, the greater were his opportunities for a decent career. Theoretical science and pure research ordinarily yielded to social survival.

On these two grounds Copernicus was shielded from temptation and from being diverted away from his great purpose. His canonry provided him with sufficient income and status, while his love for theoretical astronomy left no room for ambition and prestige. Given, however, the universal astrological orientation of his fellow astronomers in the universities, Copernicus' research had best be pursued in relative isolation from the academic world. We should have no quarrel with his admiring biographers who turn this aspect of his work into a specially glorious title.

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[69] *Stud. Cop.*, IV, pp. 440, 472–474 and *passim*. It may be relevant to observe that Machiavelli lists among the essential ingredients of power, the ability to "control" fortune (*The Prince*, ch. 25: "How much Fortune can do in human affairs and how it may be opposed", and ch. 7: „Of new dominions acquired by the power of others or by Fortune"). It is clear that by "fortune" he means all those factors beyond the close association of direct cause and effect. For Machiavelli (*Discourses*, Prologue) considers the ingredients of human affairs to be: heaven, the sun, the elements and men. One of the surest tools to harness all these factors for political action was considered to be the rules of astrological science, and all princes, tyrants, and ecclesiastical leaders were strongly tempted to make use of its services.

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THE LIBRARY OF COPERNICUS

The books which belonged to Copernicus or which were used by him during his lifetime found their way in the sixteenth century either to the Library of the Varmian Chapter at Frombork or to the Library of the Jesuit College at Braniewo. In 1626, during the first Polish-Swedish war, the Varmian collections were taken to Sweden by King Gustavus Adolphus. In Sweden most of these books remain until today at the Library of the University of Uppsala, though some of them may also be found in other Swedish libraries.

These Varmian books were identified step by step during the second half of the nineteenth and the first quarter of the twentieth centuries by Leopold Prowe, Maximilian Curtze, and Ludwik Antoni Birkenmajer, the latter at times assisted by his son Alexander or by Isak Collijn (see Table I). A complete list of those findings, comprising 45 items, was published by the Polish Academy of Arts and Sciences at Cracow in 1914 (see *Bibliography*, item *11*); it was supplemented by L.A. Birkenmajer in 1924 by three further findings [*12*]. One book described by Birkenmajer in 1900 [*8*] was omitted, probably by mistake, in the report of the Polish Academy of Arts and Sciences, one has been at the Mazurian Museum at Olsztyn since 1969, and one was identified at Uppsala in 1977. Thus the number of "Copernicana" discussed in this paper amounts to 51 books. First doubts as to the Copernican origin of some of these books were raised by Jeremi Wasiutyński in 1963 [*16*] and some books were discarded as non-Copernicana by Jerzy Dobrzycki in 1973 [*21, 23*].

During an exhibition which took place at the City Library of Toruń (December 1973 – March 1974), the Uppsala collection was generously made available for research. In that period, the staff of the Center for Copernican Study of the Institute for the History of Science and Technology of the Polish Academy of Sciences was able to make a systematic, first hand survey of the whole material. A second check of this material was made by the present author and M. Golińska-Gierych during their stay in Sweden in 1977[1].

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