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J. VERNET

RHAZES. See **Al-Rāzī.**

RHEITA, ANTON MARIA SCHYRLAEUS DE (Antonín Maria Šírek z Vrajtu) (*b.* Bohemia, 1597; *d.* Ravenna, Italy, 1660), *astronomy*.

Little is known of Rheita's life. He was a priest and a Capuchin, at first a member of the community in Vrajt (Rheita) in Bohemia. He apparently left that monastery during the Thirty Years' War, and by the 1640's was professor of theology at Trier. It is not certain when he went to Ravenna.

Rheita's work in observational astronomy and optics was carried out in Belgium in the 1640's. In 1643 he published at Louvain a tract of rather dubious scientific value entitled *Novem stellae circa Jovem visae, circa Saturnum sex, circum Martem nonnullae.* Two years later, at Antwerp, he brought out the work on which his scientific reputation rests, the *Oculus Enoch et Eliae, opus theologiae, philosophiae, et verbi dei praeconibus utile et iucundum.* This treatise contains, among a somewhat curious variety of topics, Rheita's description of an eyepiece for a Keplerian telescope that left the image reverted, his own invention; in it Rheita also made use of the terms "ocular" and "objective," which he himself had coined. Most interesting to historians of science, however, is Rheita's map of the moon, drawn according to his own observations. The map is eighteen centimeters in diameter, and although it is rather scanty in detail (and decidedly inferior to that published in Antwerp in the same year by M. F. van Langren), it is the first representation of the moon that places its southernmost part at the top, reproducing the image seen through an inverting astronomical telescope.

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Both of Rheita's surviving works have been cited in the text. There is no secondary literature.

ZDENĚK KOPAL

RHETICUS, GEORGE JOACHIM (*b.* Feldkirch, Austria, 16 February 1514; *d.* Kassa, Hungary [now Košice, Czechoslovakia], 4 December 1574), *mathematics, astronomy*.

Rheticus was the son of George Iserin, the town physician of Feldkirch, and Thomasina de Porris, an Italian lady. After Rheticus' father was beheaded for sorcery in 1528, his surname could no longer be used. Hence his widow reverted to her maiden name, de Porris, for herself and her two children. Our George Joachim de Porris tacked on "Rheticus" to indicate that he came from a place in what had been the ancient Roman province Rhaetia. Since he had not been born in Italy, he converted "de Porris" (meaning "of the leeks") into the German equivalent "von Lauchen." Then as a mature man he dropped both references to leeks, thereby transforming "Rheticus" from a geographical designation into an adopted surname. This fifth stage remained the name by which he is commonly known.

Rheticus' first teacher was his father. After the execution of his father Rheticus studied at Zurich, where Gesner was a schoolmate. He also met Paracelsus "and in the year 1532 had a conversation with him, a great man who published famous works."[1] In 1532 Rheticus matriculated at the University of Wittenberg, where he obtained his M.A. on 27 April 1536; ten days earlier he had publicly defended the thesis that Roman law did not absolutely prohibit all forms of astrological predictions, since predictions based on physical causes were permitted, like medical predictions.

In the same year Rheticus was appointed to teach elementary arithmetic and geometry at the University of Wittenberg. On 18 October 1538 he took a leave of absence for the purpose of visiting such leading astronomers as Johannes Schöner of Nuremberg, Peter Apian of Ingolstadt, and Philip Imser of Tübingen. At Feldkirch on 27 November 1538 he presented an edition of Sacrobosco (published earlier that year at Wittenberg) to Achilles Pirmin Gasser (1505–1577), who was his father's successor, twice removed, as town physician.[2] In the summer of 1539 Rheticus arrived in Frombork (Frauenburg) in order to learn from Copernicus himself about the rumored new and revolutionary cosmology.

The momentous meeting between Rheticus and Copernicus precipitated the beginning of modern astronomy. The reviver of the geokinetic system had long resisted friendly entreaties to release his masterpiece for publication, but permitted Rheticus to write a *Narratio prima* (*First Report*) about *De revolutionibus*. On 23 September 1539 Rheticus completed the *First Report*, which was published at Gdańsk in early 1540. The work was the earliest printed announcement to the educated public of a rival to the Ptolemaic system, which had dominated men's minds for fourteen hundred years. Rheticus immediately sent a copy of the *First Report* to Gasser, who promptly wrote a foreword for the second edition, which was published at Basel in 1541.[3] The first two editions of Rheticus' *First Report* did not detonate any such hostile explosion as Copernicus had feared would be the instant reaction to his geokineticism. Hence he finally made up his mind (perhaps by 9 June 1541) to let *De revolutionibus* be printed and began putting the final touches to his manuscript.

To the *First Report* Rheticus appended an *Encomium Borussiae*, a praise of Prussia based on his travels throughout that region. Presumably utilizing also Copernicus' earlier and incomplete geographical studies, Rheticus drew up a "Tabula chorographica auff Preussen und etliche umbliegende lender," which he presented to Duke Albert of Prussia on 28 August 1541. While Rheticus' "Topographical Survey of Prussia and Several Neighboring Lands" has not survived, it may have provided the foundation for the map of Prussia that was printed at Nuremberg in 1542 as the work of Rheticus' editorial assistant, Heinrich Zell. Rheticus' theoretical discussion of mapmaking, *Chorographia tewsch*, the first work he wrote in German, using his native Vorarlberg dialect,[4] was likewise dedicated to Duke Albert as a companion piece to the "Tabula chorographica." Since the duke had tried in vain to learn from other mathematicians how to anticipate the time of daily sunrise, Rheticus constructed a "small instrument for ascertaining the length of the day throughout the year." In transmitting his "Instrumentlin" to the duke on 29 August 1541, Rheticus asked Albert to recommend to both the Elector of Saxony and the University of Wittenberg that he be permitted to publish Copernicus' *De Revolutionibus*. Three days later Duke Albert complied, further requesting that Rheticus be retained in his professorship.

When Rheticus returned to Wittenberg for the opening of the winter semester, he was elected dean of the liberal arts faculty on 18 October 1541. In early 1542 he separately published—under the title *De lateribus et angulis triangulorum*[5]—the section on plane and spherical trigonometry in Copernicus' *De revolutionibus*. To this brief discussion of the *Sides and Angles of Triangles* Rheticus added a table of half-chords subtended in a circle. Such a half-chord is actually a sine, although both Copernicus and Rheticus studiously avoided the use of that term. The table of sines in the *Sides and Angles of Triangles* differs from the corresponding table in *De revolutionibus* by increasing the length of the radius from one hundred thousand to ten million and by diminishing the interval of the central angle from 10′ to 1′. Furthermore, by indicating the complementary angle at the foot of the columns and at the right-hand side of the page, the 1542 table became the first to give the cosine directly, although that term is not mentioned. Rheticus did not ascribe the authorship of this table to Copernicus nor, presumably out of modesty, to himself. Nevertheless, the table was undoubtedly his doing. His independent place in the history of mathematics is due precisely to his computation of innovative and monumental trigonometrical tables.

Although such a purely technical work as Copernicus' *Sides and Angles of Triangles* could be published without opposition in Wittenberg, that citadel of Lutheran orthodoxy was no place to print Copernicus' *De revolutionibus*, with its far-reaching cosmological implications. Hence, shortly after the end of the winter semester on 30 April 1542, Rheticus left for Nuremberg, where on 1 August 1540 a printer had dedicated to him an astrological tract. Rheticus could not remain in Nuremberg long enough to supervise the entire printing of *De revolutionibus*, since he had been appointed professor of mathematics at the University of Leipzig, where he had to be present in mid-October 1542.

After teaching three years at Leipzig, Rheticus obtained a leave of absence. He went back to Feldkirch and then on to Milan, where he spent some time with Cardano. In Lindau, during the first five months of 1547, he suffered a severe mental disorder, which gave rise to rumors that he had gone mad and died. But he recovered well enough to teach mathematics at Constance for more than three months in the latter half of 1547. Then he moved to Zurich, where he studied medicine with his old classmate Gesner, who was now a widely recognized authority. On 13 February 1548 Rheticus reported to the University of Leipzig that on the advice of his doctors he would leave at Easter to undergo hydrotherapeutic treatment and thereafter return to his post.

At the beginning of the winter semester of 1548 Rheticus was back in harness, having been elected dean. In 1549 he became involved in a legal dispute with a goldsmith and then in April 1551 in a drunken homosexual encounter with a student, on account of which he had to run away from Leipzig.

Seeking to build a new career, Rheticus resumed the study of medicine at the University of Prague in 1551–1552. Although he was invited to teach mathematics at the University of Vienna in 1554, in the spring of that year he settled down at Cracow, where he practiced medicine for two full decades. On 12 April 1564 he wrote to a friend that he had not accepted an unofficial invitation by Peter Ramus to teach at the University of Paris. In Cracow, Rheticus' lifelong interest in astrology attained its greatest success. He had followed up his master's thesis of 1536 by inserting in 1539 an astrological section in his *First Report*, although Copernicus' astronomy was entirely free of that pathetic delusion. As late as 1 March 1562 Rheticus was still contemplating—on the basis of his astrological version of Copernicus[6]—the construction of a chronology of the world from creation to dissolution. But by correctly predicting in 1571 that the successor of King Sigismund Augustus of Poland "will reign only a very short time," Rheticus acquired immense renown as a seer.[7]

L. Valentine Otho, a student of mathematics at the University of Wittenberg, was deeply impressed by Rheticus' *Canon of the Doctrine of Triangles* (Leipzig, 1551), the first table to give all six trigonometric functions, including the first extensive table of tangents and the first printed table of secants (although such modern designations were eschewed by Rheticus as "Saracenic barbarisms"). Without any recourse to arcs, Rheticus' *Canon* defined the trigonometrical functions as ratios of the sides of a right triangle and related these ratios directly to the angles. By equating the functions of angles greater than 45° with the corresponding cofunctions of the complementary angles smaller than 45°, Rheticus reduced the length of his table by half.

When Otho went to visit Rheticus in 1574, he found him in Košice, where he had gone on the invitation of a local magnate. In the arrival of the youthful student to help him publish his life's work, Rheticus recognized a replay of the scenario he himself had enacted with Copernicus a generation earlier. But unfortunately the outcome was different, for Rheticus died on 4 December 1574, leaving his books and manuscripts to Otho, who faithfully promised to see his master's massive tables through the press.

These tables were a "labor of twelve years, while I always had to support a certain number of arithmeticians for these computations," Rheticus had informed Ramus in 1568.[8] Nevertheless Otho had to cope with enormous difficulties before he succeeded in fulfilling his promise to Rheticus. Through his deceased teacher's local patron, he obtained financial support from the Holy Roman Emperor, but within two years this ruler died. On 7 September 1576 Otho appealed from Košice to the Elector of Saxony, who consented to have him appointed as professor of mathematics at the University of Wittenberg. But in January 1581 Otho refused to sign a religious formula required of all the Wittenberg professors, and therefore he had to turn elsewhere.

He found his last patron in the count palatine, Frederick IV, with whom he signed a contract on 24 August 1587. Designated the count's official mathematician, permitted to eat at the table of the professors of the University of Heidelberg, and granted the aid of four students as computers, Otho was finally able to complete and publish in 1596 Rheticus' immense *Opus Palatinum de triangulis*, as Otho entitled it in gratitude to his backer.

The foundation of the Rheticus-Otho *Opus Palatinum* is the table of sines for the first quadrant 0° to 90°, the interval being 45″ and the radius 10^{15}. For purposes of interpolation, a process of successive halving was relentlessly pursued in order to find the small angle the sine of which is 1 in the fifteenth decimal place as the first significant figure. Then, with a radius of 10^{10}, the sines and cosines were computed for intervals of 10″. The functions of each degree occupy six full pages, so enormous was the labor expended in these computations.

After Otho's death, among his papers were found additional Rheticus manuscripts, which were published by Pitiscus in his *Thesaurus mathematicus* (Frankfurt am Main, 1613). These manuscripts included a table of sines for a radius of 10^{15} and intervals of 10″, but an interval of only 1″ for the two special cases of 1° and 89°. Although Rheticus' trigonometrical tables were understandably far from perfect, modern recomputations have found them accurate to a relatively high degree.

NOTES

1. Rheticus to Joachim Camerarius, 29 May 1569 (Burmeister, *Rhetikus*, III, 191).
2. *Bibliotheca apostolica vaticana, inventario dei libri stampati palatino-vaticani*, Enrico Stevenson, ed., vol. I, pt. 1 (Rome, 1886), libri latini, no. 2195.
3. Stevenson, no. 1532.
4. Part of it was translated into modern German, and the rest summarized by Heinz Balmer, *Beiträge zur Geschichte der Erkentniss des Erdmagnetismus* (Aarau, 1956), pp. 279–286.
5. For the copy presented by Rheticus to Gasser on 20 June 1542 in Feldkirch, see Stevenson, no. 1528.
6. Burmeister, *Rhetikus*, III, 162.
7. *Ibid.*, III, 198.
8. *Ibid.*, III, 187.

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EDWARD ROSEN

RIBAUCOUR, ALBERT (*b.* Lille, France, 28 November 1845; *d.* Philippeville [now Skikda], Algeria, 13 September 1893), *mathematics, engineering.*

Ribaucour was the son of Placide François Charles Ribaucour, a teacher of mathematics, and Angélique Françoise Devemy. In 1865 he entered the École Polytechnique in Paris and in 1867 began studying at the École des Ponts et Chaussées, which he left in 1870 to become an engineer at the Rochefort naval base. At Rochefort he showed an exceptional aptitude for engineering, which also distinguished him after transfer, in 1873, to Draguignan (Var), where from 1874 to 1876 he was in charge of road construction in Var. The bridges that he designed were remarkable because of their combination of maximum strength with minimum material. From 1878 to 1885 he stayed at Aix-en-Provence, where his skills displayed in the construction works on the canal of the Durance earned him a Légion d'Honneur and a gold medal at the Paris Exposition of 1889. Ribaucour's suspension bridge of Mallemort-sur-Corrège and his construction of the reservoir of Saint-Christophe (near Rognes, Bouches-du-Rhône) were especially praised.

After a short stay at Vesoul (Haute-Saône) in order to receive the title of chief engineer, Ribaucour was sent to Algeria, where from 1886 until his death he stayed at Philippeville and worked on the construction of railroads and harbor works.

Ribaucour's mathematical work—to which he dedicated himself especially under the influence of Mannheim—belonged to his spare time, except for a short period during 1873 and 1874, when he was *répétiteur* in geometry at the École Polytechnique. His main field was differential geometry, and his work was distinguished enough to earn him the Prix Dalmont in 1877 and a posthumous Prix Petit d'Ormoy in 1895, awarded by the Paris Academy. His most elaborate work was a study of minimal surfaces, *Étude des élassoïdes ou surfaces à courbure moyenne nulle*, presented to the Belgian Academy of Sciences in 1880 (in *Mémoires couronnés et mémoires des savants étrangers. Académie royale des sciences, des lettres et des beaux-arts de Belgique*, **44** [1881]). In the work he explained his method called *périmorphie*, which utilized a moving trihedron on a surface. The approach to minimal surfaces was to consider them as the envelope of the middle planes of isotropic congruences; this approach led Ribaucour to a wealth of results.

Many of Ribaucour's papers deal with congruences of circles and spheres. Special attention was devoted to those systems of circles that are orthogonal to a family of surfaces. Such systems form *systèmes cycliques*, and it is sufficient for the circles to be orthogonal to more than two surfaces for them to be orthogonal to a family. Ribaucour's research thus led him to envelopes of spheres, to triply orthogonal systems, cyclides, and surfaces of constant curvature.

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D. J. STRUIK

RIBEIRO SANTOS, CARLOS (*b.* Lisbon, Portugal, 21 December 1813; *d.* Lisbon, 23 December 1882), *engineering, geology.*

Ribeiro was the eldest of the five children of José Joaquin Ribeiro, who was employed in the silver foundry of the Lisbon mint, and Francisca Santos. The family was poor, and Ribeiro received only the rudiments of a primary education before he went to work in a haberdashery at the age of ten. In 1833, during the War of the Two Brothers, Ribeiro enlisted, on 4 August, in the artillery and on 5 September of that year volunteered for service in the constitutionalist forces, thus severing himself from the absolutist views of his parents. When the bloody civil conflict came to