BOOK REVIEWS

A HISTORY OF ASTRONOMY

A. Pannekoek

London, Allen & Unwin, 1961, 521 pp., 24 plates
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Translated from Astronomicheskii Zhurnal, Vol. 39, No. 2,
pp. 372-374, March-April, 1962
Original article submitted January 10, 1962

A. Pannekoek (1873-1960) was a noted Dutch astronomer, Professor at the University of Amsterdam, and at one time active in promoting the socialist movement in The Netherlands and internationally. The book under review first appeared in Amsterdam in 1951, in the author's native language, under the title "De Groei van ons Wereldbeeld; Geschieden van de Sterrenkunden" (Development of concepts of the universe; a history of astronomy). The appearance of the volume in the English language makes it accessible to a wide circle of astronomers and historians of science of many countries.

In the past decade, between the publication of the Dutch and English editions of Pannekoek's work, several books have appeared which treat the "general" history of astronomy. Among them, the most important are: de Vaucouleurs' "Discovery of the Universe" (1957);* Abetti's "A History of Astronomy" (English edition, 1952); the book, "The Background of Astronomy (1957),† and a reprint of Dreyer's well-known volume, "A History of Astronomy from Thales to Kepler" (1953).‡ However, the last two books deal only with the history of ancient (in Dreyer's book, from the 6th century B. C. onward) and medieval astronomy and the early stages in the development of the modern science. The books of the Vaucouleurs and Abetti are more complete in terms of chronological scope, but both these and a number of similar works are characterized, to various degrees, by the following circumstance, a tradition which at the present time is regularly accepted but which is surely outdated: there is an underestimation (sometimes an omission), of the achievements of Ancient China and Ancient India in astronomy; a one-sided estimate of Arabic astronomy as a science developed by the Arabs alone, without consideration of the important contribution of other peoples of the medieval East; and an unfamiliarity with the many achievements of Russian and Soviet astronomical science.

In the breadth of its compass of epochs and peoples, and in its extensive application of historical material, Pannekoek's book surpasses the other "general" histories of astronomy. The volume consists of three parts of approximately the same length: "Astronomy in the ancient world" (pp. 19-170); "Astronomy in revolution" (pp. 173-307); and "Astronomy surveying the universe" (pp. 311-496).**

Pannekoek's views on the role and the importance of astronomy in the progress of mankind are characterized by the author himself in the introduction to the book, and they permeate the entire volume. Astronomy is the oldest

*Reviews in "New Books from Abroad" [in Russian], Ser. A, No. 6 (1959); Astron. Zhur. 35 (1958).
†Review in "New Books from Abroad," No. 10 (1959).
‡Review in "New Books from Abroad," No. 10 (1956).
**I give here the contents of Pannekoek's book. Part I. 1. Life and the stars (pp. 19-22); 2. Agriculture and the calendar (23-27); 3. Old Babylonian skylore (28-35); 4. Assyrian astrology (36-47); 5. New-Babylonian science (48-62); 6. Chaldean [planetary] tables (63-81); 7. Egypt (82-85); 8. China (86-94); 9. Greek poets and philosophers (95-105); 10. Calendar and geometry [in ancient Greece] (106-112); 11. Systems of world structure (113-121); 12. Hellenistic astronomy (122-132); 13. The epicycle theory (133-144); 14. The close of antiquity (145-163); 15. Arabic astronomy (164-171). Part II. 16. Dark Europe (173-177); 17. The renascence of science [in Europe] (178-187); 18. Copernicus (188-198); 19. Astronomical computing (199-203); 20. Tycho Brahe (204-216); 21. The reform of the calendar (217-221); 22. The struggle over the world system (222-234); 23. Kepler (235-244); 24. Mechanics and philosophy (245-252); 25. The telescope (253-260); 26. Newton (261-275); 27. Practical astronomy (276-281); 28. Astronomers on the move (282-288); 29. Refined practice (289-296); 30. Refined theory (297-307). Part III. 31. The world widens [Herschel] (311-320); 32. The technical basis (321-338); 33. Distances and dimensions (339-350); 34. Celestial mechanics [19th century] (351-370); 35. Plurality of worlds (371-393); 36. Cosmogony and evolution (394-402); 37. The sun (403-418); 38. Passing luminaries [comets, meteors] (419-428); 39. Peculiar stars (429-443); 40. Common stars (444-466); 41. The galactic system (467-482); 42. Into endless space (483-490); 43. The life of the stars (491-496).

of the sciences. It arose under the influence of the practical requirements of the developing human society, particularly the interest of agriculture and the establishment of a calendar for keeping track of time. Even in its later development, astronomy maintained the closest relation to the social and cultural progress of man. Having arisen earlier than the other sciences, astronomy continued to outstrip the other sciences even in its later development. It is sufficient to recall that as a result of Copernicus' discoveries astronomy first demonstrated to man that nature is not always what it seems to be, and this stimulated the succeeding development of physics and mechanics, and indeed the theory of knowledge. Having established the laws of motion of the celestial bodies, astronomy by the same token rejected the ancient mysticism and astrology. Having shown that the earth is just one of the planets of the solar system, astronomy opened the way toward an understanding first of the solar system, and later of the sidereal universe.

Pannekoek departs from the customary tradition both in questions of the organization of the history of astronomy by periods, and with regard to the role and the significance in the development of astronomy of particular peoples and their civilizations. If astronomy had outstripped the other sciences in its development, its history might not be divided at all into the same periods and epochs as the usual history of civilization . Pannekoek does not regard Arabic astronomy as the astronomy of the Middle Ages, but as the concluding chapter of the astronomy of the ancient world. In fact, Arabic astronomy preserved many of the attainments of ancient science; it strengthened the mathematical basis of Ptolemy's system of the universe, but it could not escape the bounds of the geocentric concept, and in this sense it is tied to ancient science despite its chronological position in medieval times.

Pannekoek also has an extended approach to the epoch "Revolution in astronomy." He does not regard this as a limited period of time associated with the activity of Copernicus and his immediate successors, but a lengthy epoch, comprising three centuries, beginning with the great geographical discoveries which expanded knowledge about the earth and served as a stimulus to the expansion and deepening of knowledge about the universe, and continuing to the 18th century, when observational astronomy had reached a high level, having founded on the basis of the law of universal gravitation the science of celestial mechanics, the classic model of a precise science. As Pannekoek emphasizes, the revolution in astronomy was associated with the fact that in the 15th and 16th centuries astronomy was in the center of practical life, occupying itself with problems of more vital importance than the other sciences. At the end of the 18th and the beginning of the 19th centuries, the further development of observational techniques and instruments and the first attempts to apply them — in the work of W. Herschel in stellar astronomy — to the study of the structure of the Milky Way opened a new era in the history of astronomy. This is the basis of the onset of Pannekoek's third stage in the development of the science of the universe.

The first part of the book already shows clearly how sharply Pannekoek's treatment differs from the works mentioned at the beginning of this review. He deals with a broad range of countries and peoples of the ancient world who have made a contribution of some kind to the development of astronomy. Moreover, Pannekoek overcomes the widespread traditions in western European science regarding the evaluation of the contribution of particular peoples. Thus, he gives an extremely reserved estimate of the value of Egyptian astronomy. To be sure, over its three-thousand-year existence, Egyptian astronomy did achieve some noted successes (for example, the determination of the length of the tropical year with a precision that was high for the time, although a determination just as accurate was made in China also), but it was and remained the science of the priests and for this reason alone could not leave a significant footprint on history. On the other hand, as Pannekoek points out, ancient (and medieval) Chinese astronomy, which developed in the position of a secular science, exerted a great influence on the succeeding progress of understanding of the universe. Pannekoek singles out Assyria from the whole Tigris-Euphrates science complex and demonstrates the special importance of the ancient Assyrian concept of the world (an astrological interpretation of the occurrence of particular phenomena of nature, but a rationalistic explanation if they happened to be absent at the predicted time). Considerable attention is devoted in the book to the last centuries of Babylonian science, when it continued to develop after the downfall of the Babylonian monarchy — parallel with Greek and later with Hellenistic science. Not having at his disposal the publications of the late Babylonian astronomical theaters, prepared in the 1950's by Neugebauer and Sachs, Pannekoek relied on a thorough discussion of the work of Kugler and Schaumberger, and affirmed their conclusion that even after its loss of independence, Babylonia remained a flourishing center of Near Eastern culture.

One deficiency of the volume that we must point out is that Pannekoek did not give a separate treatment of the astronomy of ancient and medieval India. He does mention some particular achievements of Indian science and its effect on Arabic (and thence on European) astronomy, but the history of Indian astronomy as a whole remains to be disclosed. There are also some objections to Pannekoek's treatment of the concept " Arabic astronomy." On the one hand, Pannekoek includes within the realm of Arabic astronomy the Berber scholars (such as Alpetragius), the Azerbaidzhan (Nasir Al-Din al-Tusi), and the Jewish (Maimonides). With this we have to agree — Arabic astronomy (and Arabic science in general) undoubtedly was the product not only of Arabs, but of other

peoples subjugated by the Arabs who used the Arabic language as an international scientific language of the East, just as in the West the Latin language held such a position for a long time. On the other hand, Pannekoek devotes little attention to the astronomy of the peoples of Central Asia, who even under the conditions of Arab conquest retained their original culture, but also used the Arabic language in their scientific literature. Pannekoek's discussion of the astronomy of the peoples of Central Asia is limited to his mention of the attainments of Ulugh Beg; the earlier great Central Asian scholars, Al-Biruni and Omar Khayyam, are not mentioned, and this, of course, detracts from the completeness of Pannekoek's exposition of the history of medieval Eastern astronomy.

In the second part of his book, Pannekoek gives much attention to the propagation of Copernicus' teachings, and to the struggle revolving about these ideas in England and in the Protestant lands of central Europe. The book shows how complicated this struggle was, in the course of which there were advanced on the one hand the "compromise" world system of Tycho Brahe, which retained the central position of the earth in the universe, and on the other the works of Thomas Digges and Giordano Bruno, with their concept of an infinite universe, extending and deepening the Copernican doctrine.

In discussing the history of astronomy a century and a half after the invention of the telescope and Kepler's discovery of the laws of revolution of the planets, Pannekoek gives special consideration to the period when astronomy saw the refinement, or perfection, both of observational practice (the work of Halley and Bradley, and the accompanying achievements of Short, Dollond, Ramsden, and other masters of the art of building astronomical instruments) and of theory (the definitive formulation of the law of universal gravitation, the work in celestial mechanics of Euler and Clairaut, of Lagrange, Tobias Mayer, and Laplace). It was this refinement that made it possible to penetrate further into the depths of the universe.

The third part of the book occupies a special place: it is concerned with the history of astronomy in the 19th and the first half of the 20th centuries. In this part, the exposition does not follow a single chronological sequence, but is arranged according to the special directions in which astronomical research has developed during the past century and a half: the astronomy of "measurement," celestial mechanics, the study of the sidereal universe as a whole, the investigation of nonstable stars, the problem of the origin and evolution of the stars, the structure of the Galaxy. These trends have persisted into the present century, in which extragalactic astronomy has originated and has received a particularly broad development, and in which a first attack has been made on the problem of the structure and evolution of stars and stellar systems. The volume closes with an exposition of the history of these last two trends. In the final pages Pannekoek expresses his own ideas on the position and the role of astronomy in modern natural science. He notes that in our time astronomy has developed in close association with the other sciences — the broadening of knowledge of the universe has rested not only on astronomical discoveries, but on physical theories and the refinement of mathematical methods of investigation. Nevertheless, astronomy remains the "science of the stars," as well as the science of the universe in the direct sense.

The survey of the history of astronomy in Pannekoek's book extends to the late 1940's. For this reason one may say that the book stops at the threshold of modern developments, but does not extend into the modern period. Too much that is new has been added to the science of the universe during the past decade and a half — this is the period during which ideas have been formulated and consolidated on the continuous process of star formation in our own and other galaxies, on the interrelations of galaxies and their origin in groups; the period which has seen the beginning of the mastery of space, and the way in which astronomy can assume the aspect of an experimental science too; and unavoidably there is a further deepening of the contact between astronomy and other branches of natural science, and many branches of technology.

We should emphasize in summation that Pannekoek's book is the most complete of the existing "general" histories of astronomy, both in the scope of the material on which it rests, and in the depth to which the author illuminates the complex course along which astronomical science has developed over the millennia. The volume is written by a well-informed scholar against a broad background of culture and history, and it closely associates the evolution of knowledge about the universe with the social and cultural history of mankind, and the development of philosophical and general scientific ideas. As we have already mentioned, the English edition of Pannekoek's book makes it accessible to an extensive group of readers. But it is very appropriate to inquire whether Pannekoek's book might be translated into Russian and published in the USSR. A Russian edition would fill a serious gap in the Soviet astronomical literature. The Russian translation of A. Berry's "A Short History of Astronomy" (2nd ed., 1946) has long been hopelessly out of date.