Lviv Observatory hosted in the last decades of eighteenth century a number of famous scientists, including Josef Lies-ganig and Franz von Zach. Actually, the paper by Apunevych and Novosyadlyj introduces the reader to the history of astronomical education and research at Lviv University. During the twentieth century, the Directors of the Observatory were Marcin Ernst (the most notable writer of popular astronomical books in Poland) and Eugeniusz Rybka (after the World War II, he was a Director of astronomical observatories in Cracow and Wroclaw, and in 1952 was elected as the Vice-president of International Astronomical Union).

One of the prominent achievements in astronomy at Lviv University involved Liesganig and his collaborators, who created the first topographic map of Galicia in 1790; then Marian Smoluchowski applied his kinetic theory to the atmospheres of planets (1900 and 1901); and Samuil Kaplan discovered the unstable circular orbits in the Schwarzschild field (1949), created a theory of white dwarf cooling (1950), and contributed to the theory of the interstellar medium. The first vertical solar telescope with a double-reflection spectrograph in eastern Europe was estabished at Lviv University Observatory.

In the next study, Savchuk and Yankiv-Vitkovska describe the second Observatory in Lviv, which was built in the 1870s. This institution was operated mostly for the needs of geodesy and education. Three prominent scientists need to be mentioned in relation to this Observatory: Dominik Zbrożek, Vaclav Laska and Lucjan Grabowski.

Ukrainians in Lviv had very limited access to high schools. Even those who obtained PhD degrees, as a rule, could only work in gymnasiums. Therefore, the Shevchenko Scientific Society (founded in 1873), in which one Section was devoted to Natural Sciences, Mathematics and Medicine, played an important role. The Chief of this Section for a few decades was Volodymyr Levytsky. He and other members of this Section published scientific papers in the fields of mathematics, physics and astronomy. They also actively promoted science (including astronomy) among Ukrainians by publishing articles and giving public lectures.

Essays in the two-volume set are thorough, with many facts found and published for the first time. Most of the authors have made significant achievements in the history of various branches of science. Their studies are based on a careful study of the archival sources and propose a deep understanding of the complex processes that accompany the progress of science. The authors create a systematic panoramic picture, which is extremely interesting to read, not only for scholars but for anyone who wants to learn about the history of culture in this part of Eastern Europe. Although the focus of the book is on the various stages of research and education in Lviv, it also objectively highlights important international and state-building processes.

Special attention should be paid to the illustrations, which include many unique photographs and copies of documents. The authors went to considerable effort to find them, many of which are published for the first time. Each of the papers in this book contains a detailed bibliography that will be useful for future researchers. Without doubt, this large-scale project will be greatly appreciated by the scientific community.

This book, in the Ukrainian language, was published under the auspices of the Institute for Applied Problems in Mechanics and Mathematics of the Ukrainian National Academy of Sciences. The papers were collected and scientifically edited by Oleh Petruk. An elegant edition of the book was prepared and published by the Artos publishing house. The publication appeared thanks to the good will of the sponsors, who are co-founders of the IT company SoftServe, which is now the largest employer of talented young people in Lviv with a good mathematics and physics education.

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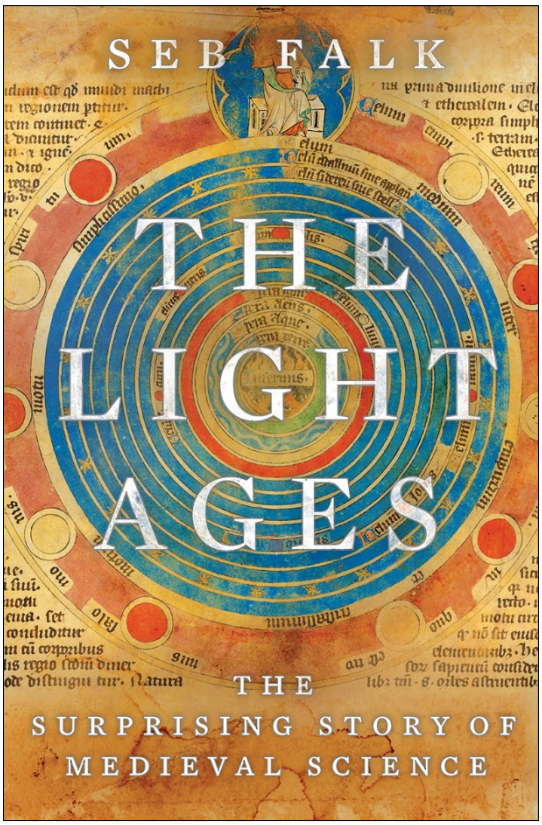
***The Light Ages: The Surprising Story of Medieval Science*, by Seb Falk (New York, W.W. Norton and Company, 2020) Pp. 391, ISBN 9781324002932 (hardcover), 160 × 230 mm. US $30.00.**

The Light Ages: The Surprising Story of Medieval Science is by Cambridge historian and lecturer Seb Falk who specializes in the history of astronomy, navigation and mathematics from their early development through the Middle Ages into the contemporary period. Falk puts to rest the obsolete and long-discredited notion that referred to the medieval period as 'The Dark Ages' and illuminates the advancements in scientific knowledge as well as the spirit of experimentation that actually existed. To illustrate his survey of astronomical theories and advances, Falk researched

the compelling story of a fourteenth-century monk-scholar-astronomer-crusader, Johannes de Westwyk, tracking his life through his writings and scattered references found in various documents. *The Light Ages* tells the tale not only of the struggles, research and accomplishments of Westwyk, but the world around him; the emerging sciences and technological achievements in timekeeping, mechanical clocks, optics, astronomical instruments, navigation and medicine. Falk defines and appraises the … "irresistible medieval drive to tinker, to redesign, to incrementally improve or upgrade technology." Using Brother Westwyk's life and achievements as an anchor that he returns to over and over in



his ambitious tome, Falk guides the reader through the intellectual advances and understanding of science, especially astronomy in the Pre-Renaissance world of Europe.

John of Westwyk received his basic education and then took monastic vows at the Benedictine Abbey of St. Albans, Hertfordshire, England in the 1370s. Many medieval abbeys were lonely, isolated spots devoted to prayer, poverty and subsistence farming but not St Albans. Dating back to the eighth century and honoring England's first martyr, the wealthy complex comprised numerous imposing buildings and functioned as a lively center of economic, societal and religious activities—an artistic and intellectual hub. Located one day's journey on the main road north from London, the comfortable abbey offered hospitality to Royalty in transit, as well as bishops, emissaries and scholars passing to and from Oxford University, just fifteen miles further north.

St. Albans boasted many famous members of their monastery including Richard of Wallingford (1292–1336), the leprous clockmaker, and Matthew Paris (c.1200–1259), the celebrated writer of the *Illustrated Chronicles; Observations of Thirteenth-Century Life.* Paris' writings detailed and illuminated British and world historical events and religious activities. He created many important maps culled from well-traveled pilgrims and even crusaders who visited the abbey. Paris also produced a book on astrology that discussed the work of Hermann Contractus or the Lame (1013–1054), even drawing his picture. Hermann of Reichenau had written on sundial, mathematics and *The Uses of the Astrolabe* with instructions for making one.

Abbot of St Albans from 1327 until his death, Richard of Wallingford's astronomical clock was the wonder of Britain and sat in the south transit of the abbey church until 1539 when it was destroyed during Henry VIII's dissolution of the monasteries. The huge clock, measuring eight feet across, displayed the Sun and Moon moving across the sky at varying speeds, as well as the accurate phases of the Moon and the lunar nodes. J.D. North published an excellent edition of Wallingford's writings in 1976 fully describing the clock's intricate workings. Called 'the world's most advanced astronomical clock', its numerous wheels and dials were so complicated that it was not completely finished until twenty years after Wallingford's death. Westwyk would have viewed the great clock at least seven times a day during the mandatory canonical hours of prayers chanted by the monks throughout each day and night.

The medieval Church had a reputation for discouraging scientific advancements, but Falk demonstrates the opposite was true. Friar John and other monks and priests were encouraged to attend university for higher education. Westwyk's writings indicate he attended Oxford although no proof survives. The clergy were expected to acquire knowledge of astronomy and mathematics necessary for measuring time and making precise astronomical observations for creating accurate Church calendars. Monks used astrolabes and other scientific instruments and often maintained records of exact planetary and stellar positions. The positions of the

planets as they moved through each constellation of the zodiac were made, copied, corrected and re-calculated by trained monks. Tracking the appearance of certain stars at special points, between two windows, over a tower, or on the horizon would signal the proper time for their daily prayers and announce feast days.

Citing Westwyk as a medieval university student, Falk presents an extensive survey of the curriculum offered at that time through the Seven Liberal Arts and the widely-read astronomical textbook of Johannes de Sacrobosco, *De Sphaera*. A beginning text often used was Priscian's *Institutes of Grammar.* Three branches of philosophy (moral philosophy, natural philosophy and metaphysics) were studied, as well as the contributions and importance of Islamic scientific scholars such as Al-Farghani, Abu Ma'shar and Al-Biruni, and the basic role astronomy and astrology played in medieval medicine.

Eventually Brother Westwyk was transferred to a small Northumbrian abbey, Tynemouth Priory, built on a rocky outcrop overlooking the North Sea, which must have tested the vows of the bright and curious astronomer. Another monk described the "… dense and gloomy fogs … [that] dull the eyes, hoarsen the voice and constrict the throat …", adding that "… spring with its flowers is outlawed there; summer warmth is banned …" (page 180). Even worse, his new priory library had only "… a dozen or so books." (page 181). He must have brought along a few since he continued his studies and astronomical observations, charting the planetary positions and movements of the heavens.

Falk picked up traces of Westwyk's life again in 1383 when he joined a crusade along with six other monks of St Albans lead by the Bishop of Norwich, Henry de Despenser. Perhaps fighting on crusade was more appealing than the boring life in gloomy Tynemouth that saw no summers. In return for the promise of enormous spiritual benefits and indulgences, numerous participants from all occupations joined the crusade against the loyalists of the Antipope Clement VII ruling from Avignon. The Papal schism had split the Catholic Church and two popes (later three) claimed legitimacy. The schism was tied to the Hundred Years War between England and France. Initially the campaign was successful, but not for long; the army began to suffer losses and then succumbed to dysentery. The religious crusade set off with great hopes in May 1383 but by the end of September had retreated to England in defeat.

After Westwyk's return from the dreadful battles, there is no record of the astronomer monk's whereabouts for ten years until he reappears staying at a London inn or guesthouse of St Albans Abbey. There, complaining of pig-filled streets, he wrote his final manuscript, an instructional manual for constructing a scientific instrument of his own invention and explanation of its use as an astronomical device which he called *Equatorie of the Planetis*. Falk begins his book discussing this manuscript, which was first discovered in the 1950s in the Cambridge Peterhouse Library, MS 7, dated 1392. The manuscript was suspected to be the author's draft of a treatise on the astrolabe and was initially attributed to Geoffrey Chaucer who wrote the *Treatise on the Astrolabe* in 1391 but Chaucer scholars could never prove it. Surprisingly it was written in Middle English not Latin used in all Church documents, which also pointed to Chaucer.

Much later, the actual author was discovered by Norwegian scholar Kari-Anne Rand after comparing the identical writing style of the *Equatorium* to Westwyk's previous manuscript called *Albion* that was discovered in 2000. This manuscript was another compendium of astronomical calculations signed Johannes de Westwyk and based on Richard of Wallingford's work. He had created the work at St Albans for their monastic library. Actually in 1379 Westwyk had copied and annotated two Latin manuscripts on the use of astronomical instruments originally written by Wallingford.

Westwyk personally interacted with the English poet and astronomer and cites him through his writings. Based on Arabic astronomical writing, Chaucer's *Treatise on the Astrolabe* included two parts, the instrument's description and an explanation of its use. Westwyk's text and the tables comprising his *Equatorium* manuscript are arranged in a similar manner. He may have modeled his work on that manuscript; he also included new terms coined by Chaucer. Many Arabic words had been absorbed into astronomical writings; even the Moslem invocations were adapted by Christian astronomers. More than twenty words or phrases have their first English appearance in Westwyk's handwriting; most were astronomical terms or parts of the instrument he made in order to make their meaning clear. Although mathematics was generally still recorded in Roman numerals, Westwyk created his astronomical tables in Indian-Arabic numbers. He wrote in the vernacular to make the instructions understandable for tradesmen to construct his 'planetary

computer'; just as Chaucer had written for his ten-year-old son.

The *Equatorie of the Planetis* described a large instrument, six feet across, which Westwyk specially designed to calculate the positions of each planet with surprising precision. Throughout his manuscript you can follow his thinking as he worked; he crossed out words and noted further explanations. Falk explains the construction and operation of the *Equatorium* in excruciating detail, which would have worked better as an appendix for the truly devoted historians and astronomers. All but the most interested and advanced readers will probably skim the lengthy and involved description of the construction and operation of the astronomical device. After this manuscript production there has been no further information on Johannes de Westwyk yet discovered.

Falk's book (named a Best Book of 2020 by *The Telegraph*, *The Times*, and *BBC History Magazine)* is divided into seven finely crafted chapters in which he manages to revitalize the medieval period with its variety of interesting personalities, theological doctrines, and cosmological theories that reach into numerous areas. Study of nature and of the heavens was a fundamental part of medieval lives, including those in religious orders. Falk contends that rather than being isolated in their monasteries, medieval monks were influenced by an "… international scientific fraternity of Jews and Muslims, Italians and Germans." (page 121). They were eager to keep up with intellectual progress and the latest scientific discoveries. There was no contradiction in being a monk and a scientist.

Through the life of a single, undistinguished, but captivating monk, Falk touches on all aspects of medieval life, on the monks' Rule of St Benedict, chanting, prayer, memorization techniques, canon law, the movement of books in monastic libraries, the Albigensian Crusade and the Black Death. Almost drowning in exacting details, he describes the Roman calendric system of Kalends, Nones, and Ides, the Muslims and Jews in Spain. He mentions innumerable personalities who made contributions to medieval astronomy, including Walcher of Malvern, Pedro Alphonso, Constantine the African, Gerard of Cremona, Roger Bacon and Robert Grosseteste, explaining the scientific explosion before the Renaissance. Falk notes that for medieval people, the "… study of the world – that is, the whole created cosmos – was a route to moral and spiritual wisdom." (page 295).

This survey, or reader's guide, to the Middle Ages, with 62 illustrations, is well constructed and tediously researched. It seems overly ambitious, at times trying to cover all bases; in some areas too tedious for newcomers and then covering too much well-known material for those knowledgeable in medieval studies.

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Mars, by Stephen James O'Meara. (London, Reaktion, 2020). Pp. 230. ISBN 978-1-78914-220-4 (hardback), 180 × 230 mm, US$40.00.

Mars by Stephen James O'Meara is the latest in a series of Kosmos books by Reaktion Press on the Solar System. Published to date are volumes on Jupiter, Mercury, Saturn, The Moon, and The Sun. In the interests of full disclosure, my Asteroids book in the series was published in May 2021.

O'Meara, who has asteroid 3637 named in his honour, is a well-known writer of popular astronomy books, and his association with *Sky & Telescope* and *Astronomy* magazines has brought his name to the attention of everyone interested in astronomy. His fluid prose is always a delight to read, and nowhere has it been more needed than this book on Mars, where terms such as cyanobacteria, sputtering, andesitic lava and crystal magnetic field litter the text. Not all of these are explained, but 11 pages of references are given for the reader who wants to explore further.

An example of his writing to make complex issues more relatable is his mention of ice ages on Mars.

> In contrast to Earth's ice ages, a Marian ice age waxes when the planet's poles warm up ...They wane when the poles cool and lock water into polar ice caps … Understanding the ice caps' Jekyll-and-Hyde behaviour is important for future missions to Mars, so we can plan where the water will be when we send astronauts to the planet. (pages 89–90).

Specifically, on the topic of history of astronomy, O'Meara has a rich history of Martian studies to choose from. The first 50 pages of the book are an extremely fine synopsis of this history, beginning with a finely-crafted sentence, "Mars has burned its imprint on the human imagination ever since stargazers first pondered its appearance in the night sky." (page 7). A resident of Botswana, O'Meara begins with rock drawings dated to 70,000