The next chapter presents the famous *Atlas Coelestis*, published in Nuremberg in 1742. The atlas documents the astronomical and cosmographic knowledge of the early 18th century on 30 double-sided, artistically illustrated color plates (format 530 mm × 630 mm). They cover the solar and planetary system according to Tycho and Copernicus, planets and their orbits, transits, surfaces, moons and phases. The maps show the celestial hemispheres with comet orbits and star catalogs, the Moon and the geography of the Earth. A high-quality facsimile edition of the *Atlas Coelestis* was published in 2014 by the Albireo Verlag, Cologne.

The last chapter deals with the Doppelmayr globes. The first were made in 1728: a pair of celestial and terrestrial globes, now on display at the Bibliothèque Nationale de France (Paris). 102 terrestrial and 101 celestial globes with a diameter of 10 cm to 32 cm have been preserved. Unfortunately, Doppelmayr was unable to produce larger globes. The three chapters are followed by an appendix entitled "Die Globen der Andreae" ("The Globes of Andreae"). It's about the curious story of Doppelmayr's competitor in Nuremberg, which ended in a legal dispute in 1733/1734.

The second volume closes with Doppelmayr's bibliography (30 pages), archive materials (20 pages), literature (53 pages) and a list of people (33 pages). There is no subject Index.

Hans Gaab's latest publication is a treasure trove of scientific history that leaves nothing to be desired. It will undoubtedly become the standard work on Johann Gabriel Doppelmayr—unfortunately in German. The author shows what is possible with an exceptional combination of expertise and accuracy. The clearly written text offers insight into an important period in the development of astronomical methods, maps, globes and instruments. The extensive work is recommended to anyone interested in the history of science. It is also likely to be an inspiration for scientists working in this field.

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***Splinters of Infinity: Cosmic Rays and the Clash of Two Nobel Prize-Winning Scientists Over the Secrets of Creation*, by Mark Wolverton. (Cambridge, MIT Press, 2024). Pp. viii + 271. ISBN 978-0-262-048828 (hardback), 155 × 230 mm, US$29.95.**

As one might expect from a seasoned science journalist, this is a well-written expose on a highly technical subject: in this case, cosmic rays. While historians of science would certainly like to see more raw meat (technical diagrams, equations and extensive quotations of academic papers), this is a first-rate introduction to a subject that touches equally on physics and astronomy. The human dimension to the early study of cosmic rays, which would normally be given nothing more than a supporting cast role in an academic book, is here elevated to a clash between two superstars: Robert Millikan and Arthur Compton.

Mark Wolverton, who has previously written books on Oppenheimer, the Pioneer planetary spacecraft, and the science of Superman, here turns his journalistic eye to a long-running drama that largely played itself out in his own chosen field: journalism. He is thus ideally placed to explore and put in context the long-running interaction these two Nobel Prize-winning physicists had with the news media in the 1930s.

It took 20 years from the time cosmic rays were discovered "… until it was conclusively determined that … [they were] coming from outer space." (page 10). It was Robert Millikan (Nobel Prize in Physics, 1923) who proved they were not coming from Earth's atmosphere or the ground, and he was the scientist who dubbed them cosmic rays. And yet his view of what cosmic rays are—nothing less than the 'birth cry' of the Universe, which aligned with his religious beliefs —was at such variance with reality that this great pillar of his career toppled. One might profitably read an elegy to an ancient ruined temple in tandem with this book.

There is a prescient photograph in the book, taken at the 1931 Rome conference. On the left is Millikan, who is engaged in conversation with Marie Curie (Nobel Prize in Physics, 1903, and in Chemistry, 1911). Between them, Arthur Compton (Nobel Prize in Physics, 1927) listens intently. Curie told the conference she and her colleague W. Bothe had created an artificial cosmic ray in the laboratory, and that she agreed they came from deep space. Millikan hoped that Curie's statement at the conference was going to end the cosmic ray battles as to their origin. But

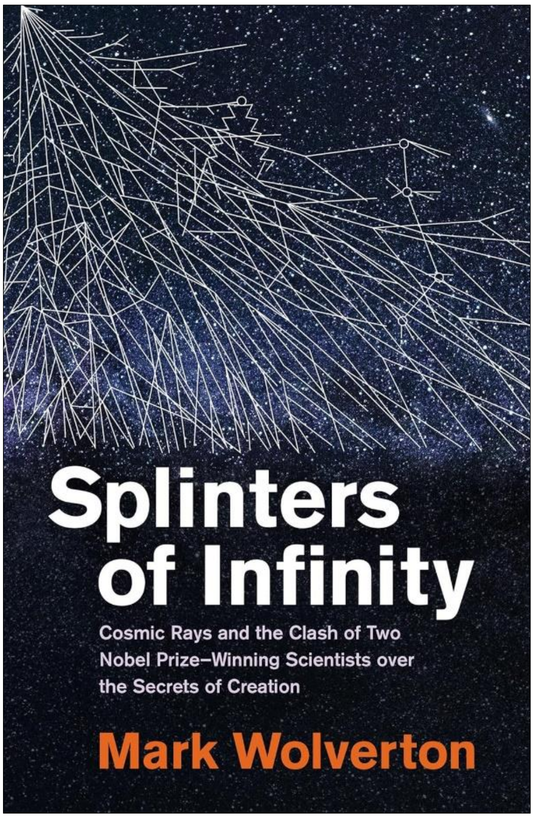
> Instead, he would soon discover that the man who would become his staunchest opponent had found in Rome his inspiration to pick up his sword and shield and take up the struggle in earnest. (page 12).

By painting this in the highly romantic terms of a Medieval knight, Wolverton sets out on a Crusade in this book to show how Compton slew the dragon, Millikan.

The trigger that set Compton off on his quest was a presentation at the 1931 conference by Bruno Rossi. This 26-year-old took on the 63-year-old Millikan with all the rashness of youth. He wrote "The main thrust of this talk was to present … irrefutable arguments against Millikan's theory of the 'birth cry' of atoms." (page 9). Less than six months later, Compton kicked off a global campaign to solve the mystery of cosmic rays. Much of this book details that campaign, which stretched from polar wastelands to deep mines, mountain peaks and dense jungles. The *New York Times* ran a front-page story on it, in the 3 January 1932 edition. Many other newspapers carried the torch. On 8 September that year, the *Boston Globe* reported that Sir Arthur Eddington did not believe that cosmic rays were continuously generated as Millikan maintained, and that they may actually date to the origin of the Universe: "Sir Arthur believes that Prof. Millikan has much to learn yet about cosmic rays and where these rays came from." (page 112). Counterbalancing these Eastern newspapers was the *Los Angeles Times*, which staunchly supported Millikan, and reported on virtually any utterance he made.

The crux of the debate surrounded the nature of cosmic rays. Compton's idea that they are 'electrical particles' was inconsistent with Millikan's views. The *Los Angeles Times* put this esoteric choice to its readers in the starkest religiously-toned terms possible. Wolverton writes that the newspaper "… couldn't resist observing that the fate of the universe was apparently at stake." (page 104). If Millikan was correct, the *LA Times* told its breathless readers, "The faith of those who believe the universe constantly is being re-created and will never die will be strengthened." (page 104). In the event, Compton was right. Faced with evidence Compton developed, Millikan adopted the most unscientific stance possible. "The precise nature of these rays is not important …" he wrote in 1933, and then did a volte face by saying cosmic rays originate in the destruction of matter, not its birth. Thus, the great Millikan, in complete denial, faced the denouement of his career. His address at a London physics conference in 1934 was characterised by Compton as "… largely a stage for Millikan to present his views, which were received with a distaste approaching nausea by his British listeners." (page 195). By 1936, Compton was on the front cover of TIME magazine.

Wolverton also tracks the accompanying (false) assertion by Compton that cosmic rays did not originate from outer space. Even now, it is not entirely certain where they come from, but a cosmic origin is certain. During



the period studied in this book, many high-altitude measurements were made to pin down the source.

Since one balloon flight (sponsored by Compton, Millikan, and others) follows another, chapter after chapter, it is a bit difficult to put them in context and rank them in importance. Some were record-setting flights for altitude, others were better known for their attempted scientific experiments, while others were embarrassing failures. A table of all these flights with their key characteristics and names of the balloonists would have been most helpful. The later flights, which were unmanned, should also be included.

A fine example of popular science writing; it is well-sourced, with 19 pages of Notes. The book will appeal not just to laymen but to astronomers and physicists who are not familiar with the early twentieth-century struggle to understand cosmic rays.

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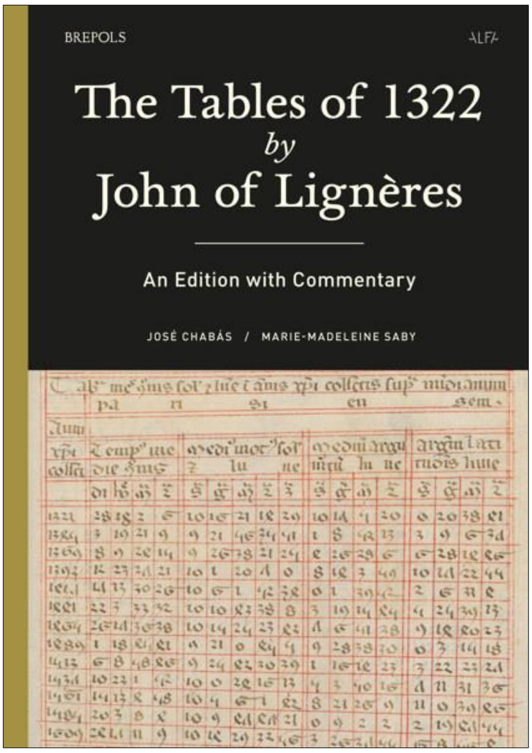
***The Tables of 1322 by John of Ligneres: An Edition with Commentary*, by José Chabás and Marie-Madeleine Saby. (Turnhout, Brepols, 2023). Pp. xxiii + 221. ISBN 978-2-503-59609-9 (hardback), 178 × 254 mm, Euro65.**

In Toledo in the middle of the thirteenth century, Alfonso X of Castile coordinated the compilation of a collection of astronomical tables to succeed the late eleventh-century Toledan Tables that had dominated European astronomy. The original Alfonsine Tables (composed in Castilian), not extant today, found their way to Paris, and in the 1320s a lively attention to astronomy there led to their translation into Latin. These Parisian Alfonsine Tables (PAT) spread far and wide, and were still being used 300 years later. Exactly what happened between the Toledan and Parisian Alfonsine Tables is not completely settled and will require more research to resolve.

The present volume concentrates on one of the table collections between these two bookends, just before PAT: the Tables of 1322 by John of Lignères. He was one of the leading figures in the intellectual ferment of the 1320's; aside from these tables, he wrote a number of works, including two canons (instructions for using astronomical tables) today called the *Cuiuslibet* and the *Priores astrologi* after the opening words in these texts. The latter work in particular refers frequently to the 1322 Tables. This book presents editions, commentaries, and discussions of variants of the 32 tables that the authors consider to be included within the collection, based on a careful study of ten of the 46 known manuscripts. When dealing with medieval collections of astronomical tables, it is often difficult to draw firm boundaries between them, given that the 'toolbox' nature of tables led to regular borrowing of tables between collections. In this case, although there are a couple of inclusions or exclusions that one might debate whether they belong (for instance, the three tables of velocities of the Sun and Moon, all of which have the same purpose), the 1322 Tables are quite coherent, clearly a unit to themselves.

The 32 tables fall roughly into three groups. The first seven cover trigonometry and spherical astronomy, such as the solar declination and right and oblique ascensions. The next six deal with various aspects of the motions of the Moon and planets, such as their latitudes, retrogradations, and phases. Curiously, the fundamental tables of planetary motion—mean motions in longitude and equations—are not to be found here. Instead,



John of Lignères compiled those in his later *Tabulae Magne*, including double argument tables for the planetary equations. The remaining tables, more than half the work, present what is needed for the prediction of eclipses.

This book includes, in addition to scholarly editions of each table, three subsections for each table: titles in other manuscripts, a description, and variant readings. The descriptions point out salient facts about the table, as well as probable historical sources. Many of the 1322 Tables derive from the Toledan Tables, and from there backward to al-Battānī's *zīj* and further back to Ptolemy's *Almagest* and *Handy Tables*; some are related to the Almanac of Azarquiel. The con-