whose views of the cosmos were repeatedly shown to be at odds with reality. Sobel quotes from his letters to give us a real-time sense of what he was thinking on the great issues of the day. In July 1918, while World War I was still raging, Shapley wrote to Edward Pickering

> I believe the most important photometric work that can be done on Cepheid variables at the present time is a study of the Harvard plates of the Magellanic clouds. (page 170).

This is a perfect example of the warning, 'be careful what you ask for'. Shapley believed our Galaxy was the entire Universe, but a study of Cepheid variable stars, particularly in the so-called 'Andromeda Nebula', proved that our Galaxy is one of many. It was Edwin Hubble in 1924 who found a Cepheid in the Nebula, showing it is at least a million light years away. Instead of just mentioning such a discovery in dispassionate scientific terms, Sobel puts us in the moment with this dramatic sentence:

> After Shapley read Hubble's news and looked at the light curve, he held out the pages to Miss Payne, saying, 'Here is the letter that has destroyed my universe.' (page 204).

I have just mentioned the Harvard plates, which, along with the ladies, are the co-stars of this book. Thanks to the large and continuing grants of money from Anna Palmer Draper, Harvard was able to establish a suite of telescopes in various countries to advance astronomical research. The centrepiece of this work was photographic, and resulted in hundreds of thousands of plates that contained the treasures of the Universe. It was this treasure trove that was mined by dozens of young women whose lives and careers are sensitively traced by Sobel. She looks at those who achieved immortal fame, such as Annie Jump Cannon, Antonia Maury and Henrietta Leavitt, along with many others who are nearly forgotten. Some of these dedicated women literally worked themselves to death in the cause of science, and this book serves as a fine testament to their efforts.

The index has some issues. For example, the asteroid Eros is listed with several page entries, but its appearance on pages 155 and 160 are missing. The 8-inch Bache telescope at Harvard College Observatory is likewise given several page references, but its mention on page 72 is missing from the index. Fairfield's entry is given twice, once under Fairfield, Priscilla and again under Bok, Priscilla. These are just three examples.

Despite my minor quibbles, Sobel has produced a readable and engaging account of how modern astrophysics developed, and the crucial role of women in that grand endeavour.

Dr Clifford J. Cunningham
National Astronomical Research Institute of Thailand, Chiang Mai, Thailand.
Email: Cliff.Cunningham@usq.edu.au

***Discovery of the First Asteroid, Ceres*, by Clifford Cunningham (Springer International Publishing, 2016). Pp. xiii + 333. ISBN 978-3-319-21776-5 (hardback), 157 × 240 mm, €129.99.**
***Early Investigations of Ceres and the Discovery of Pallas*, by Clifford Cunningham (Springer International Publishing, 2017). Pp. xix + 412. ISBN 978-3-319-28813-0 (hardback), 157 × 240 mm, €149.99.**

This five volume series covers historical studies in asteroid research and, judging by the first two volumes reviewed here, this project will be an all-encompassing compilation and definitive study of this topic. Building upon and substantially revising the author's earlier work in many areas, Cunningham combines a historian's love of detail with a sense of the wider impacts of events to retell one of the great stories in the development of our understanding of our Solar System through the application of mathematical tools that has focused the power of human intellect to understand the nature of the Universe.

These two books follow a common structure: the introductory chapters cover the main topics and draw upon correspondence between the major figures to advance the narrative. Subsequent chapters reproduce books, correspondence and letters to provide an original source perspective on the events of the time. This is one of the books' major strengths, namely the publication in English of original sources regarding historical developments. Cunningham illustrates the broader impact of events through examples of verse and art. The illustrations enrich the story and include images of people covered in the narrative, together with cover pages of major publications.

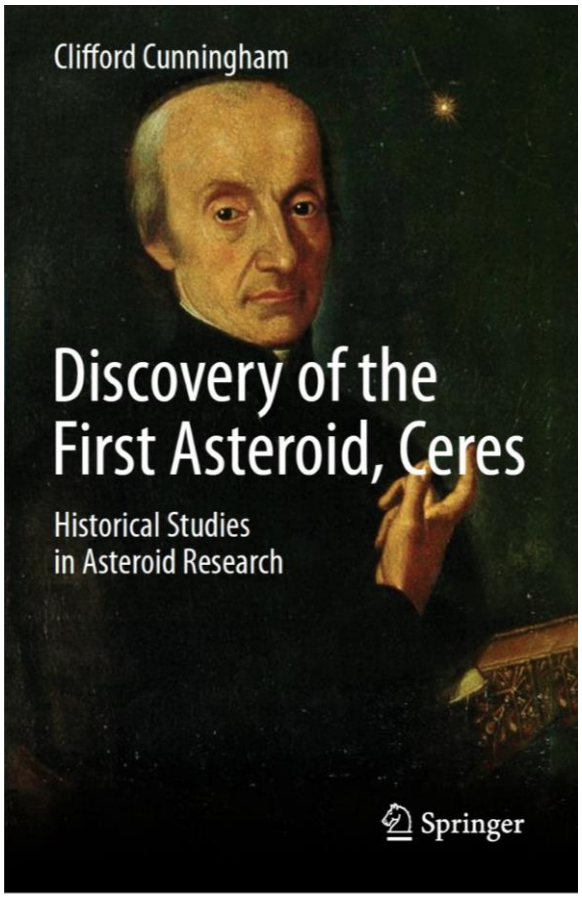
Another strength of these volumes is the connection that the author makes between the tight world of professional astronomy and the broader aspects of human society. The impact of new discoveries on literature and art is presented by numerous excerpts from noted writers and by many illustrations from publications of the times communicating discoveries to the broader public.

Volume One, Discovery of the First Asteroid, Ceres

After tracing the idea that there just might be another planet between Mars and Jupiter back to its origin with Kepler, Cunningham describes its development as a mathematical relationship relating the size of planetary orbits in the introductory chapter. Herschel's discovery in 1781

cemented the validity of this theory when Uranus fitted nicely into the framework. Plausibly there was an undiscovered planet there so European astronomers set out to find it. Chapter 2 relates the intriguing story of how Ceres was actually discovered, including errors made along the way. The following chapter covers one of the great stories in astronomy: the recovery of Ceres due to the mathematical genius of Gauss when observational searches proved fruitless. This chapter is enriched with an essay by Brian Marsden recounting this recovery. Chapters 4 and 6 describe the ensuing controversy over naming of this new world and how the public first learned about Ceres.

Chapter 5 describes the initial efforts to determine the physical properties of Ceres and the realization that it did not fit any of the models for what a planet or a comet should be.



Books by Piazzi, Bode and Schroeter, and correspondence and letters between the leading figures in this story are included in Chapters 7–14. Four appendices flesh out details of the instrument that Piazzi used to discover Ceres, a chronology of the events of 1801, development of the orbital elements of Ceres and a recounting of the various star charts that played a crucial role in the discovery.

The story of their success is interwoven with the personalities and politics, along with contextual international events. What sets this volume apart from previous works is the comprehensive detail that Cunningham has assembled. Numerous interesting details bring human elements to the story such as the account of Cacciatore on the events surrounding the discovery of Ceres and the subsequent efforts of Piazzi to minimize the importance of his role. Cacciatore's alternative perspective points out the all-too-human characteristics of who history records as great discoverers. Piazzi's eagerness to receive full credit is further illustrated by the apparent efforts that he took to make it difficult for others to find Ceres in the sky. The collecting of original communications, publications and notes, all presented in English, provides a valuable resource for any student of asteroid science and the scientific historian.

There are only minor issues with this volume. The section in Chapter 2, page 38, titled "When Was Ceres Seen for the First Time", leaves the reader puzzled as to what the answer is. This rather vague recounting adds little to the question. Also, the caption to Figure 2.3 on page 29 states that "Figure 2.3 show the seven stars from Piazzi's …" However this figure actually depicts the front and back of a medal.

Finally, an update. The table on page 89 now needs to be modified to reflect the DAWN determination of the size of Ceres (a mean diameter of 588 miles), rather than using Millis' 1987 value.

Volume 2. Early Investigations of Ceres and the Discovery of Pallas

The first five chapters of this volume cover a wide range of topics, from the general state of mathematics in European countries to the origin of the word 'asteroid' to describe Ceres and the other bodies found in this region of the Solar System. Chapter One explores the role of mathematics in understanding the world and then explores why there were fundamental difference between the methods of celestial mechanics as practiced in France and Germany. This difference was crucial as the French failed to succesfully predict the location of Ceres, while Gauss, with the German influence (Ramism), succeeded. Cunningham inserts his own perspective:

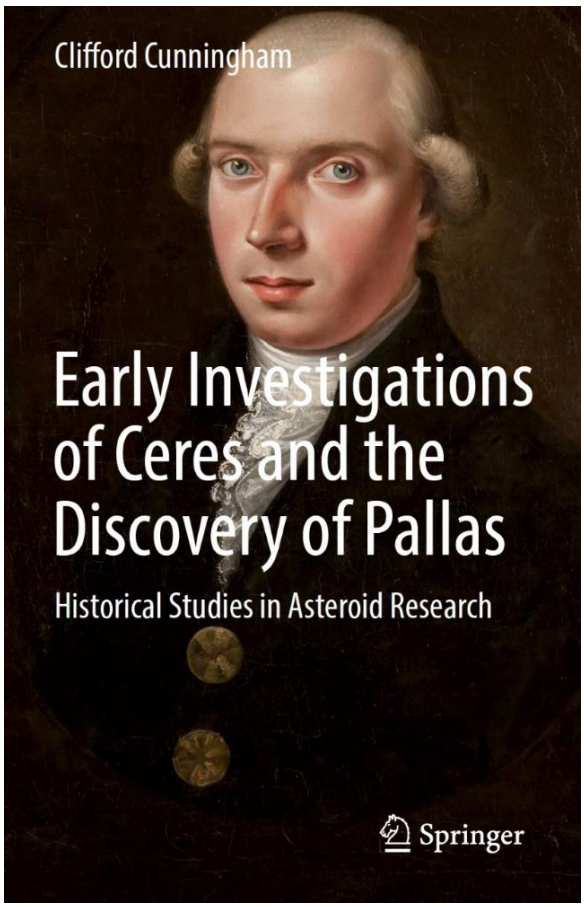
> I contend that one of these new aspects arose in the study of celestial mechanics around 1800. My analysis does not suggest that Ramism was deliberately or consciously employed in this effort that found its greatest expression in the recovery of Ceres. (page 12).

One need only look ahead 45 years to the discovery of Neptune to see how the fortunes of French celestial mechanicians had improved.

Chapter 2 compares the state of science and mathematics in France with that of Germany,

with a bit of England and English satire thrown in, while Chapter 3 explores professional rivalries among the leading German, French and English astronomers of that time. The following chapter recounts the origin of the term 'asteroid' to describe these newly discovered objects that clearly did not belong to the same class of objects as the planets. The section on "What is a Planet? A View from the Eighteenth Century" raises a question that invokes deeply held opinions even today and will likely undergo further revisions as our knowledge of exoplanets expands.

In Chapter 5 we arrive at The Discovery of Pallas by Olbers, on 28 March 1802. Rather than describing the discovery events in detail in his own words, Cunningham tells the story as told



in the words of Olbers himself from a letter. Few words are spent on the actual discovery before the narrative moves on to a discussion of the nature of Pallas. This is followed by a discussion of the 'exploded planet' hypothesis of Olbers, presented on 15 May 1802. The remainder of this chapter deals with Bode's attempt to preserve his law and an extensive section on how the public learned of the discovery of Pallas. More details of the circumstances of the discovery of Pallas would be welcome here. While Olbers was searching for another planet, in the broad sense, he was following Ceres on 28 March—so was it sheer luck that Pallas was close by, thus enabling its discovery? Did Olbers have a broader strategy in his search for a new world? Why was Olbers looking for another planet in the first place, since Ceres had filled the gap between Mars and Jupiter? Appendix B gives the positions of Ceres and Pallas in 1801–1802, but the ephemeris for Pallas (Figure A2) covers only dates in April and May, not 28 March. Giving the location of both bodies on the discovery date would enable the reader to judge the degree to which chance was crucial in the discovery of Pallas.

Chapters 6–10 reproduce original logbooks, letters, books and scientific papers by various participants in this story and contain interesting insights into the origin of various ideas. For example, Ende suggested to Olbers that Pallas might have resulted from a cosmic catastrophe (the 'exploded planet hypothesis'), but is never given credit for this, as Cunningham notes. Another example is in the letter from Gauss to Olbers where Gauss introduces the idea that these bodies might collide:

> Both paths would come frightfully close together at a place not far from the area where the two stars are. Our descendants could perhaps some day be spectators of the most terrible phenomenon: the collision of the two celestial bodies!

Today studies of asteroid collisional evolution are a fundamental component of understanding the origin and evolution of this population.

These two books are definitive works on the discoveries of Ceres and Pallas and provide deep insights into the broader context and impact of these events. They are intended primarily for the historian of planetary science and those interested in the impact of new discoveries in science on human culture. While the vast amount of material assembled in these volumes may be intimidating for the casual reader, they do provide a rich resource for both serious researchers and students of asteroidal history. Cunningham has done a great service to this field by producing these works.

Dr Donald R. Davis,
Planetary Science Institute, Tucson,
AZ 85719, USA.
drd@psi.edu

***Roman Portable Sundials: The Empire in Your Hand*, by Richard J.A. Talbert. (Oxford, Oxford University Press, 2017). Pp. xxi + 236. ISBN 9780190273484 (hardback), 170 × 240 mm, US $55.**

Richard Talbert, the William Rand Kenan Professor of History at the University of North Carolina, is the world's leading authority on ancient geography. He has now brought this expertise to bear on portable sundials that embody