

given above. However, this is not due to a lack of effort on the author's part, it is simply due to the fact that many of the ancient Babylonian, Egyptian and Greek manuscripts were destroyed or lost over time. Bernardi fills in, though, with interesting historical notes regarding ancient customs and astronomical knowledge. This book would be useful as a reference, but is confusing in places due to an incorrect usage of personal pronouns. A more careful edit would have made it easier to read.

*The Unforgotten Sisters* will be appreciated by anyone interested in the history of astronomy or women in science and mathematics. It will be of particular benefit to girls wishing to pursue a degree or career in astronomy as it highlights achievements made by women through sheer determination. All readers will come away with a high regard and an appreciation for each of these women and the individual challenges they faced while pursuing a greater understanding of all things astronomical.

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***The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars*, by Dava Sobel. (New York, Viking, 2016). Pp. xii + 324. ISBN 978067001952 (hardback), 160 × 235 mm, US\$30.**

The popular science author Dava Sobel has produced some excellent books, and one that is questionable. My favourite one is *Letters to Father* from 2001, consisting of letters written to Galileo by his daughter. Her 1995 book *Longitude* unfairly maligned Great Britain's Astronomer Royal, Nevil Maskelyne, as a villainous character. She is back on solid ground with this book about the women who by virtue of their intelligence, dedication and largesse played a pivotal role in the development of astronomy at Harvard Observatory in the late nineteenth and early twentieth centuries.

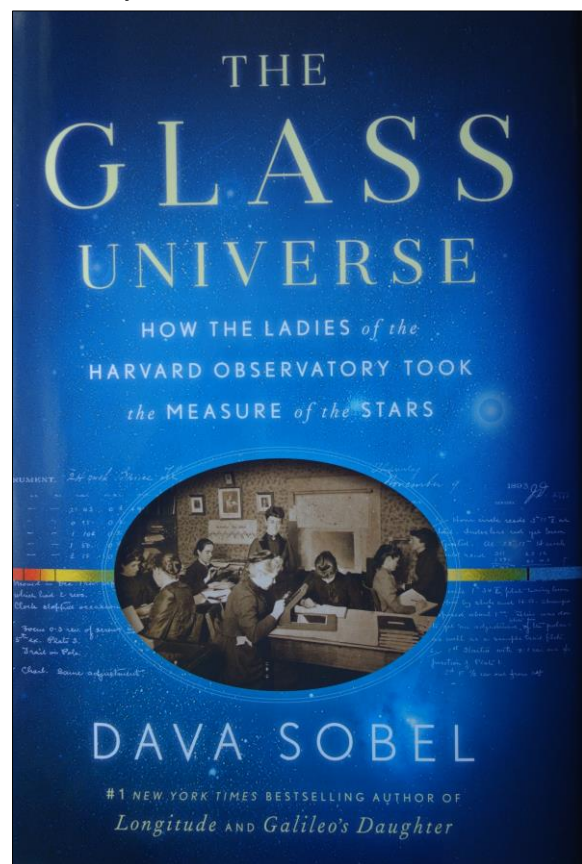
Elements of the book were especially interesting to me as I knew several of the people Sobel writes about. These include Bart Bok, and Helen Sawyer Hogg, who officially opened my own observatory dedicated to asteroid photometry. The timeline at the conclusion of the book includes Dr Hogg's marriage in 1930 and her award of the Annie Jump Cannon Prize in 1950. However, the timeline is inconsistent as it notes the passing of some, but not all, women who feature in this book. Among these missing entries are Drs Hogg and Priscilla Fairfield, in 1993 and 1975 respectively. In 1921, Fairfield was one of the first women to receive a Ph.D. in astronomy. She began working at Harvard in

1923,

... comparing the spectra and proper motions of giant and dwarf stars belonging to Draper class M, in order to more clearly define the line distinctions between them. (page 217).

Sobel tells us that Fairfield was able to pay her student assistants 30 cents an hour to help, thanks to a \$500 grant from the National Academy of Sciences.

In 1928 Fairfield attended "... the largest and most global gathering of astronomers ever united." (page 223). This was in Leiden, where 243 delegates, including 14 from post-world war Germany, met to discuss all aspects of astronomy. Sobel informs us "The moment Miss Fairfield stepped off the train at the Leiden station, she attracted the attention ..." of a certain Dutch astronomy student. Miss Fairfield



... tried to fend off the amorous advances of her new suitor, who, at twenty-two, was a good ten years her junior. Bart Bok persisted, however, and at length overcame her misgivings. (page 224).

Miss Fairfield thus became Mrs Bok. This extract is given to show one of this book's great strengths—the interweaving of both professional and personal information, which provides texture to the great story Sobel offers us.

While she concentrates on the ladies of Harvard Observatory, Sobel necessarily must also delve into the careers of the men who ultimately ran the place. Among these is Harlow Shapley,

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.

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***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