gravitational wave physicists, all of whom are members of an international group of over a thousand scientists engaged with the detection apparatus at two widely separated sites, one in Livingston, Louisiana and the other in Hanford, Washington. The emails researchers in the collaboration exchanged and the queries Collins sent to the physicists who acted for him as "key informants" provide the bulk of the material for Collins' "real-time" observations of this discovery in the making.

At times, Collins finds the community of researchers exasperating and wrong-headed in their, in his view, overly secretive attitudes to their results. But Collins is not a detached witness of the events he describes and analyses. Instead, he is overall a highly enthusiastic fan of the gravitational wave community. Collins has not sought out for *Gravity's Kiss* the kinds of evidence one might have expected a historian to have pursued.

*Gravity's Kiss*, however, should be read on its terms. It is a work of reportage from an "embedded" sociologist of science with long experience of, and valuable connections in, the gravitational wave community. Along the way, he offers sharp insights into the working of these scientists. Collins proves to be an excellent guide to the operations of a "Big Science" collaboration and the intense scrutiny of, and complicated negotiations around, the "[v]ery interesting event on ER8."

Robert W. Smith
University of Alberta
rwsmith@ualberta.ca

## "Girl-Hours" at the Harvard Observatory

*The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars.* Dava Sobel (Viking Penguin Random House, New York, 2016). Pp. xii + 324. $30. ISBN 9780670016952.

In 1869, Harvard's new president, Charles W. Eliot, asserted that

> [t]he world knows next to nothing about the natural mental capacities of the female sex. Only after generations of civil freedom and social equality will it be possible to obtain the data necessary for an adequate discussion of women's natural tendencies, tastes, and capabilities.[1]

It would take more than 50 years to get to the starting line of female suffrage, but Eliot was in no hurry. In the midst of his many reforms to the university, there was one thing he could not abide: the higher education of women. He only tolerated the establishment of Radcliffe College in 1894 because the Harvard President and Fellows would approve its faculty appointments; the Overseers were resolved that no woman should ever earn a Harvard degree. The goal of Radcliffe instruction, in Eliot's mind, was to make the young women better helpmates to their husbands and families.

As readers of Dava Sobel's book will learn, a more progressive stand was taken at the Harvard College Observatory, a few blocks up Garden Street from the Radcliffe and Harvard Yards. Edward C. Pickering, the director from 1877 to 1919, and his successors, Solon Bailey and Harlow Shapley, were beholden to many women in carrying out the observatory's programme of photometric and spectroscopic research. If we follow the

money, we can see how. Anna Palmer Draper funded the Henry Draper Memorial, which classified stars based on analyses of photographs of their spectra. Catherine Bruce paid for the most powerful photographic telescope in the world when it was completed in 1893. The Bruce telescope joined other instruments sent by the Harvard College Observatory to Arequipa, Peru, and then to Bloemfontein, South Africa in order to photograph the southern sky on glass plates. Plates of the northern hemisphere were taken in Massachusetts. As hundreds of thousands of photographic plates stacked up, Pickering needed a lot of labour to reduce the data in order to catalogue the stars in brightness and composition. He could not afford to hire more men. Women were cheaper, more patient, and detail-oriented. The first "computers" were daughters of Harvard faculty and astronomical observers. Qualified Radcliffe students landed unpaid internships. In 1895 and 1896, Henrietta Swan Leavitt and Annie Jump Cannon came from these ranks before being employed at an hourly wage of 25 cents. Between 1885 and 1927, the observatory employed some 80 women who studied glass plate photographs. Shapley boasted about the factory-style work. There was "a tremendous amount of measuring. I invented the term 'girl-hour' for the time spent by the assistants. Some jobs even took several kilo-girl hours. Luckily Harvard College was swarming with cheap assistants; that was how we got things done" (p. 189, rephrased following the original).

Sobel details the work of these assistants in *The Glass Universe.* Included are Williamina Fleming, who first found work as Pickering's maid but soon specialized in variable stars and rose to become head of the computers; Leavitt, whose discovery of the period–luminosity relationship of Cepheid variables led to a new method for measuring the dimensions of the universe; Cannon, who created the Harvard Classification System for stars and personally catalogued more than a quarter million; and Cecilia Payne, whose doctoral research found the great abundance of hydrogen and helium in the stars. Sobel considers the daytime computers to be astronomers as much as the night-time male observers were. She credits Pickering and Shapley for giving them more credit than was doled out to women elsewhere at the university. Nonetheless, the observatory directors were products of their times and clear disparities persisted in social hierarchy and pay. Fleming was the first women to hold a Harvard Corporation appointment as Curator of Astronomical Photographs but complained in 1900:

> [Pickering] seems to think that no work is too much or too hard for me, no matter what the responsibility or how long the hours. But let me raise the question of salary and I am immediately told that I receive an excellent salary as women's salaries stand. If he would only take some step to find out how much he is mistaken in regard to this he would learn a few facts that would open his eyes and set him thinking. Sometimes I feel tempted to give up and let him try some one else or some of the men to do my work, in order to have him find out what he is getting for $1500 a year from me, compared with $2500 from some of the other [male] assistants. Does he ever think that I have a home to keep and a family to take care of as well as the men? But I suppose a woman has no claim to such comforts. And this is considered an enlightened age! (p. 96)

Dava Sobel knows how to tell a good story, as readers of her first book, *Longitude*, know. *The Glass Universe* is a collective biography. Drawing on letters, diaries, observatory annals, and annotated photographic plates, Sobel sticks to the facts and does not invent

romances or jealousies for which we have no evidence. Some readers will be disappointed that the book does not have a strong or dramatic storyline (as *Longitude* did), but it is a better piece of historical scholarship as a result.

### Note

1. C. W. Eliot, "Inaugural Address," in N Pusey (ed.) *A Turning Point in Higher Education* (Cambridge: Harvard University Press, 1969), pp. 17–8; cf. idem, "Radcliffe Commencement Address," *Harvard Graduate's Magazine*, 7, no. 25, 1898, p. 83.

Sara J. Schechner
Harvard University
schechn@fas.harvard.edu

## Amateurs in American Astronomy

*Charles Olivier and the Rise of Meteor Science.* Richard Taibi (Springer, Cham, 2017). Pp. xxxii + 497. €107. ISBN 9783319445175.

Given the lack of historical works on meteor science in the United States in the twentieth century, no doubt a reflection of the relative low status of the field in astronomy, Taibi's contribution to the Springer Biographies Series is most welcome. Not only does it add to our knowledge of the history of meteor science, albeit with a limited chronological scope, but it is also a significant contribution to the history of amateur science in the United States.

The book consists of two parts. Roughly 60 percent is a biography of Charles P. Olivier, a history of meteor science in the United States, and a history of the American Meteor Society (AMS), all intertwined. This intertwining is completely defensible. Olivier was the leading meteor scientist in the United States between the world wars and served as president of the Meteor Commission of the International Astronomical Union from 1925 to 1935. He was also founder of the AMS in 1911 and remained its president and dominant figure until 1973. For decades, he personified meteor science in the United States.

Why did Olivier decide to focus on meteor science when it was an obvious backwater in American astronomy at the turn of the twentieth century? Taibi offers a fascinating, although ultimately unprovable, thesis. Olivier was born and raised in a Virginia household and community that glorified the Confederacy and bemoaned the defeat of the South during the Civil War. Taibi suggests that Olivier saw meteor science as a "Lost Cause," analogous to the South, which he could champion and ultimately rehabilitate.

Unfortunately, the biography and the two intertwined histories of meteor science and the AMS are terminated in 1936, the 25th anniversary of the founding of the AMS. This somewhat arbitrary endpoint leaves a number of important questions unanswered. Given Olivier's identification with the segregated American South (he ended up living the first half of his life there), how did he adjust to moving North to the University of Pennsylvania in 1928 and residing in the Philadelphia area during the Civil Rights era (he died in 1975)? How did his approach to meteor science change, if at all, when the Smithsonian Astrophysical Observatory became a major player in meteor science after World War II?