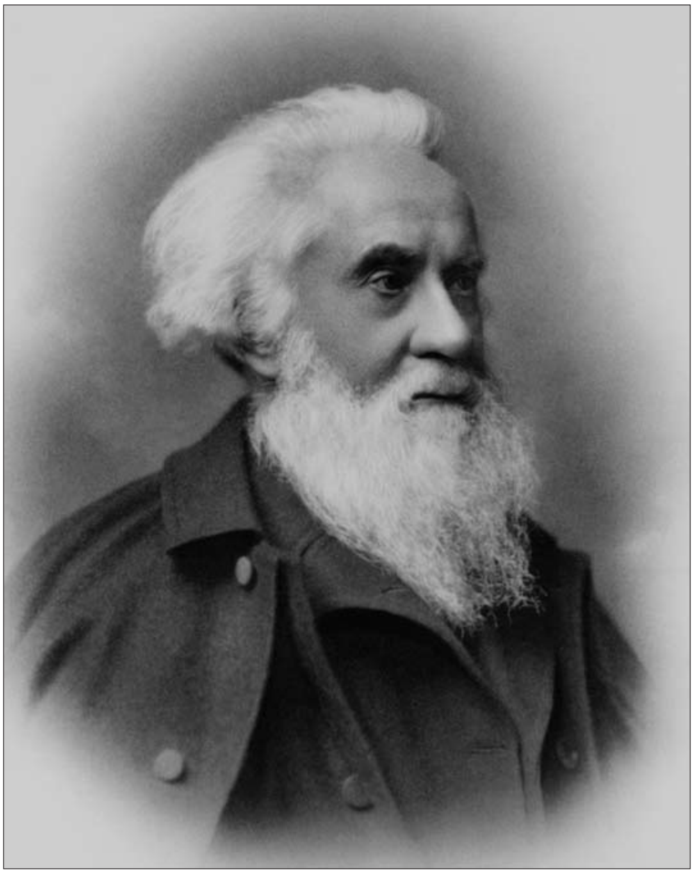
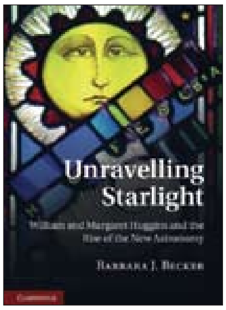
Behind the narrative





Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy
Barbara J Becker, 2011, Cambridge University Press, £65, hbk.

William Huggins's achievements in establishing spectroscopy as a tool in astrophysics are very well known, not least because in his later years he wrote a popular account of his career – *The New Astronomy* – and his redoubtable wife and fellow observer, Margaret, published a posthumous biography that was very widely read. These two documents paint an engaging picture of the astronomer at work, supported by his wife. *The New Astronomy* (reprinted as part of this book), in particular portrays William's career as a seamless sequence of challenges overcome and discoveries made, and has become almost an archetype of discovery and innovation in science. And the development of spectroscopy and the new areas of astrophysics it enabled in the second half of the 19th century is a very good story.

The trouble is, it didn't really happen like that, as Barbara Becker's engaging and informative book makes clear. The accepted narrative, written by William himself, is very readable, a considered and finely crafted account, as Becker points out ; overall, it is far too good to be true. The problem, of course, is that great scientists, looking back over their careers, can all too easily fall into the pattern of presenting their progress as a steady climb, tougher in some parts than in others, but driving steadfastly towards their goals. It seems natural that they don't mention the digressions, the byways, the ideas that didn't work out, or the things they tried but lost interest in. Yet such accounts leave the reader with the impression that some people, great scientists, proceed from triumph to triumph without a misstep. Lesser mortals bumble along, heading into dead-ends and spending time on projects that lead nowhere, eventually, accidentally perhaps, getting somewhere. Nothing, of course, could be further from the truth, and this book unearths what the Hugginses really did – and it is a much more interesting story.

Sharp eye and wit

Becker has stepped back from received wisdom as presented in the accounts written by the Hugginses, and examined the original documentation of William's life, preserved in scientific libraries across the world, not least the Library of the Royal Astronomical Society at Burlington House. The book is well illustrated, with many of the original sketches and details of their instruments, and notably well sourced. Detailed footnotes underpin the excellent story; the author's sharp eye and wit underline the contrast between received wisdom and historical fact in this snapshot of the birth of astrophysics. By examining William's notebooks, publications (and even their referees' reports, in some cases) Becker has unearthed a far more fitful and realistic progress of ideas from a man who, while he became a pillar of the establishment, started off as something of an outsider. He rose as a result of inspired scientific thinking and diligent observation – along with a healthy dose of what we would now call public relations.

Detective work

This book represents a considerable achievement in academic detective work, which took the author some 20 years to complete. The picture that emerges is very different from the image cultivated by William and Margaret Huggins themselves, and is far more complex and more interesting. The great man of science is uncovered as someone with his roots in commerce, who never attended university, and whose work took many a wrong turn as well as the inspired directions that led to his success. He worried about money, about scientific precedence and getting credit for his discoveries; he had feuds and disagreements in the international scientific world of 19th-century astronomy, not least with Sir Norman Lockyer, and he was very pleased to receive the honours and accolades that came in later life. In short, William had a lot in common with many an academic today. Far from revealing his feet of clay, and making him seem a lesser figure, Becker's work makes William a much more real and believable figure, and so makes the development of instrument-based science in the 19th century a useful comparator for the changes that astronomy is undergoing today, moving further away from the observer at the telescope.

It is a commonplace observation today that modern observatory practice separates the observer from the data and that analysis of the data alone cannot give the same insight as shivering in an observatory collecting it all yourself, despite the tremendous increase in information available. William's story spans the birth of the science of astrophysics, as distinct from astronomical observation. Photography and spectroscopy became essential tools of astronomy, largely because of William's work, but they were not available to all astronomers, and thus threatened to change a subject that had been available to all who could look through a telescope and describe or sketch what they saw – albeit a limited group in itself. But the quantification of astronomical observations and the development of astrophysics as an end in itself would limit it further. In some ways, this process was a key step to the professionalism of astronomy, fostered later by the establishment of the great observatories, especially in the US. Here again there are parallels with the changes astronomy is undergoing at the moment, with access to cutting-edge observatories and instruments becoming limited by national prosperity and appetite for science.

Competitive nature

There was also a seemly but hard-fought battle for precedence and position going on throughout William's life. He was always aware that he started as an outsider, establishing Tulse Hill Observatory on the profits of his family's silk business. He felt the competitive nature of scientific research keenly, and disliked other people using his ideas and techniques to outdo him. There is another parallel with today's scientific world here, beyond the fight for precedence in publication: the role of the popular press. William felt that Lockyer had an invaluable tool in the magazine *The Reader*, which Lockyer established and wrote for extensively. Today, press releases and pre-publication announcements, far too often premature and later retracted, detract from a clear understanding of who did what, when and where. William, you feel, would not approve.

This book also addresses the role of Margaret Huggins, long considered an exemplar of the "helpmeet" role assumed by astronomers' wives and female relatives in the 18th and 19th centuries. As Becker points out, these helpful ladies are only some of the invisible and unacknowledged army of family, friends, servants, neighbours, manufacturers and so on who made the work of the pioneering astronomers possible, while in general disappearing from the official record of the work. The late Mary Brück's account of the work of women in astronomy (*Women in Early British and Irish Astronomy: Stars and Satellites* 2009 Springer RAS Series) dispels the myth that this essentially subservient role of helpmeet was the only way in which women worked in astronomy, but it is a pervasive image and one that fits the official Margaret Huggins, despite her role as co-author of some of Huggins's most significant publications.

Becker's research makes it clear that Margaret was indeed a force in astronomy in her own right. True, she took on the role of keeping the notebooks in the Tulse Hill Observatory, but she was noting down both her and her husband's observations and ideas, distinguishing between them and doing her share of the work . She was the person who introduced photography to their research, for example, after some years in which William was aware that photography would help his work, but appeared unable to master the techniques. On the basis of the notebooks and other documentation unearthed by Becker, it is clear that Margaret was a true co-author not only of those papers that bear her name, but of others published by William alone. Theirs was a collaborative partnership, not the leader and follower that tends to be assumed.

Scientific team

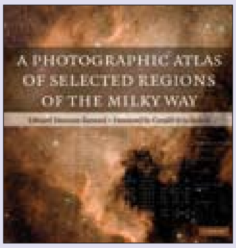
Why, then, do many of the popular histories and accounts of the Hugginses' work allow this interpretation? Becker feels that in part this comes from an interpretation of their work in terms of the modern hierarchical pattern of scientific collaboration. We expect there to be a leading author, and assume that the Hugginses worked in that way too, especially when we think back to what we know of the position of women a century ago. The notebooks and letters Becker consulted suggest a much more equal partnership in the very different circumstances in which they lived. The most powerful reason for thinking of Margaret's role as less scientifically significant than it was is the evidence presented by the Hugginses themselves. In life, William displayed a shrewd understanding of the power of a good public image, fostered by the story of his career he told in *The New Astronomy*; Margaret continued the tradition after his death. William and Margaret do not seem to have been iconoclasts, and their presentation of their scientific roles contained nothing that would rock the boat in society. They seemed content to reinforce the roles of scientist and amanuensis, rather than the scientific team that their observatory notebooks record.

Indeed, William himself was not an advocate of women members of scientific societies, and Becker notes that it was Margaret's decision that he was too ill to attend that meant he was absent on the occasion that the Royal Society decided to award the Hughes Medal to Hertha Ayrton in 1906. He later wished that he could have attended and voted against the award, although he did not speak out in the terms used by a Fellow of the RAS, who suggested that admitting women to the Society would result in the need for music and dancing during papers presented there.

That Society, at least, has changed, but many aspects of science have not. *Unravelling Starlight* is a stimulating and enjoyable book, presenting a narrative of the life and work of the Hugginses that goes beneath the accepted history of their many discoveries. Beckers shows that the Hugginses developed a far more interesting, more modern and intriguing partnership than had been thought. The book overall is a powerful argument against taking great scientists at their own estimation – history, properly unravelled as it is here, will be the judge.

Sue Bowler

Dark arts, revisited

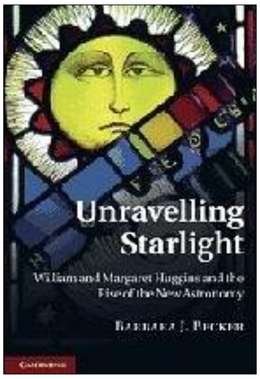


A Photographic Atlas of Selected Regions of the Milky Way
Edward Emerson Barnard, Gerald Orin Dobek, 2011, Cambridge University Press, £75, hbk.

This is a reprint of the famous atlas of dark objects that was published in 1927, some years after the death of its author, Barnard, a publication that has proved an inspiration to generations of astronomers, including Gerald Dobek of Northwestern Michigan College. Dobek has rearranged the original material to show the plates and charts on facing pages and produced a summary chart showing the locations of all the plates across the sky. It is a handsome volume, and Dobek has added to its appeal with a foreword and a short biography of Barnard, who started his career in a photographic studio at the age of nine, and finished it as Professor of Practical Astronomy and Astronomer at Yerkes Observatory, Wisconsin.

BOOK REVIEWS

Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy **by Barbara J. Becker (Cambridge, Cambridge University Press, 2011). Pp. xix + 380, ISBN 978-1-107-00229-6 (hardback), US$172.00.**



The rise of astrophysics has been the subject of considerable scholarship, ranging from the writings of David DeVorkin, Jack Meadows and others exemplified in the *General History of Astronomy*, to John Hearnshaw's detailed *Analysis of Starlight* (1986) and the special issue of this journal covering the first century of astronomical spectroscopy (Volume 13, July, 2012). Once considered an oddity among classical positional astronomers, in the twentieth century astrophysics came to dominate the field, revealing the nature of astronomical objects that the philosopher Auguste Comte famously declared would forever remain hidden to the human mind.

In the volume under review, Barbara Becker focuses on William Huggins, the man widely hailed as the founder of astronomical spectroscopy. It is a striking fact of history that Huggins (1824–1910) had no formal university education, and yet leapfrogged the professional astronomers of his time in expanding the theory and practice of astronomy to the new realm we now know as astrophysics. Becker examines how this happened in great detail, in the process providing a signal contribution to the history of astronomy.

Huggins could easily have remained in his father's business as a silk mercer and linen draper, never entering the field of astronomy. But instead, to the everlasting benefit of astronomy, he sold the business and pushed forward with his personal interests. Despite his lack of formal training, in 1856 Huggins built a rudimentary observatory in Tulse Hill, a suburb south of the Thames in London. He erected a new observatory at the end of 1862, which included an 8-inch Alvan Clark refractor he had acquired four years earlier. He began reporting startling results in 1864. What allowed him to obtain these novel results was spectroscopy, for Huggins's new observatory was "… the only work space of its kind in the world …" (page 58), with all manner of chemicals and chemical apparatus, batteries, Bunsen burners, and vacuum tubes spread around. With the help of his friend and neighbor William A. Miller (a Chemistry Professor at Kings College, who was skilled in laboratory spectroscopy), Huggins was able to set up not only an observatory, but an astronomical laboratory. This was the beginning of what a recent volume (David Aubin et al., *The Heavens on Earth*, 2010) dubs the "… observatory sciences …," analogous to broader laboratory sciences that historians have analyzed. Huggins and Miller proved to be an ideal team to bring spectroscopy into astronomy; and one of the themes of Becker's book is the necessity of crossing boundaries in creating a new discipline.

Chapters 5 and 7 detail Huggins' most famous discoveries: the gaseous nature of some nebulae, and stellar radial velocities. It is notable that both discoveries were made in the 1860s (1864 and 1868 respectively), very early in Huggins' investigations. Arguably, never again in his long career did Huggins match the fundamental nature of these discoveries, supporting the view (important even today for science policy makers) that new technology tends to yield its most fundamental discoveries early on. Becker's nuanced view of the discovery of nebulae shows that it was not as clear-cut as Huggins himself portrayed it more than three decades later in his personal retrospective on "The New Astronomy" (1897), often cited as the definitive description of his discovery. Becker sees Huggins' article as "… an alluring trap …" for the historian, and she looks beyond his description to argue that the discovery was likely much more complicated than pointing and seeing.

Huggins' discovery of stellar motion in the line of sight, today known as radial velocities, was perhaps even more fundamental than his determination of the gaseous nature of some nebulae, leading to a broad research program. In Huggins' time, however, the project was "… fraught with overwhelming mensurational and interpretive difficulties …" (page 104), a fact we tend to forget today when radial velocities are mass-produced. Becker uses observational notebooks to show how Huggins overcame these challenges, and how he had to persuade astronomers his measurements were real. For the star Sirius, for example, Huggins measured a velocity of 24 to 43 miles per second (the value today is about 6 miles per second). Much larger radial velocities of *galaxies* later became essential, especially with V. M. Slipher's work in the early 20th century, eventually leading to evidence for the expanding Universe. Stellar radial velocities continue to be essential to astronomical research, and have now been refined to such an extent they are one of the essential methods for detecting planets beyond our Solar System, as variations of stellar radial velocity due to perturbing planets are measured down to the meter-per-second level.

Throughout his long career Huggins occasionally followed up on his path-breaking work on nebulae and radial velocities, but more often he turned to other objects, including the Sun, planets, comets and novae, preferring to open new lines of research. In this he was aided by the Royal Society, which in 1871 equipped his observatory with a 15-inch refractor and an 18-inch reflector, with spectroscopic attachments. Huggins' relation with the Royal Society is another important theme of the book, illustrating how an amateur astronomer could break into the circle of the professionals.

In addition to the considerable published record (the *Scientific Paper*s were compiled by Huggins and his wife Margaret in 1909), Becker makes excellent use of archives around the world; indeed, it is the use of this unpublished material that makes her study so valuable. In particular, in addition to unpublished correspondence, the Hugginses' observatory notebooks covering the years 1856 to 1901, now located in the Wellesley College Special Collections in the USA, detail for the first time the important role of Margaret Huggins.

This points to another salutary feature of the book: it is important not only for the new historical details it reveals, but also for the broader themes it illuminates. True to her title, for example, in Chapters 10, 12 and 15 Becker demonstrates the essential role of Margaret Huggins as a working partner with her husband, a working relationship that seems even more substantial than Caroline Herschel's role with her brother William. Margaret was Huggins' junior by a quarter century; she was 27 and he was 51 when they married in 1875. Yet by all accounts it was a happy marriage, all the more because of Margaret's serious interest in astronomy. More than a partner, Becker argues that Margaret helped shape the research agenda of the Tulse Hill Observatory, in particular when it came to photographic spectra, since Margaret had photographic skills even before she met William Huggins. Together they pioneered the use of the dry-gelatin photographic plate as applied to spectroscopy.

Becker also draws attention to the largely-forgotten but recently-resurrected work of Ludwik Fleck on the changing boundaries of scientific disciplines, arguing that Huggins' work can best be seen in the context of his "thought collectives," circles of specialized and peripheral individuals that interact in complex ways. Huggins the outsider, she argues, gathered close associates, but in order to be successful also had to break into the larger collective of professional groups such as the Royal Society. She is attentive to social issues, including how an 'amateur' astronomer could make such fundamental discoveries and how he became accepted in the world of professional astronomy. While Becker does not characterize her book as a comprehensive definitive biography, it is something much more, a nuanced biography that illuminates broader themes in science. For this reason, it will be of interest not only to historians of astronomy and astrophysics, but also to historians and philosophers of science in general.

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BOOK REVIEW

Barbara J. Becker: *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy*

Cambridge University Press, Cambridge, UK, 2011, ISBN: 978-1-107-00229-6, 380 pp, price: $110.00

Alan Hirshfeld

Published online: 27 December 2011

In 1854, thirty-year-old English silk merchant William Huggins sold the family business, moved with his parents to the upscale London suburb of Lambeth, and started observing the cosmos the way it had been done since Galileo's time: by peering into the eyepiece of his telescope and letting the heavenly light flood his retina. Astronomy was the perfect hobby for Huggins, given his affinity for the sciences and his financial means. Although not formally trained in the field, he was, by nature, a detail man and came to be almost obsessive—in a productive way—toward his astronomical avocation. He was soon elected to the Royal Astronomical Society, purchased a used telescope from fellow amateur astronomer William "Eagle-eye" Dawes, and added an enviable two-story observatory onto his already substantial house on Tulse Hill.

By the summer of 1860, having nosed around the edges of planetary and double star studies, Huggins received word of a momentous discovery by German physicist Gustav Kirchhoff: the perplexing array of dark lines in the solar spectrum—the Fraunhofer lines—might be used to deduce the chemical constituents of the Sun. No longer did the Sun's remoteness, and much more so, the stars', place them frustratingly out of reach of laboratory analysis; to the contrary, their ever-steady streams of light delivered their chemical signatures right to Earth.

Many decades later, in a much-read biographical retrospective titled *The New Astronomy*, William Huggins famously described his reaction to the birth of cosmochemistry:

> This news was to me like the coming upon a spring of water in a dry and thirsty land. Here at last presented itself the very order of work for which in an indefinite way I was looking – namely, to extend [Kirchhoff's] novel methods of research upon the sun to the other heavenly bodies. A feeling as of inspiration seized me: I felt as if I had it now in my power to lift a veil which had never before been lifted; as if a key had been put into my hands which would unlock the unknown mystery of the true nature of the heavenly bodies [Becker (2011), p. 331].

Coming across this passage, now some 10 years ago, the scientist in me thrilled to Huggins's realization of his purpose in the scientific quest. In fact, I immediately added his words to my file of science-related quotes. But at the same time, the writer in me balked at

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his labored double metaphor—the lifting veil, the unlocking key—either of which would have sufficed to evoke the supreme moment of inspiration. Was this just a Victorian-era flourish? Or was it a retrospective—presumably conscious—effort on Huggins's part to heroicize his considerable accomplishments?

As a pioneer of one of the most productive tools in the modern observatory—the spectrograph—William Huggins deserves to be better known, especially among astronomers. He was first to use the instrument to observe emission lines in the spectra of nebulae, apply the Doppler effect to estimate the line-of-sight velocity of stars, and identify ultraviolet spectral lines on a photographic plate. He suggested a plausible means of observing solar prominences outside of an eclipse. He was twice awarded the Royal Astronomical Society's Gold Medal; received honorary degrees from Cambridge, Oxford and Edinburgh; and was knighted by the Queen. His observatory on Tulse Hill rivaled those of the best institutions in England. Yet, in writing *The New Astronomy*, might he nonetheless have felt the need to more securely stake his claim to be the founder of celestial spectroscopy?

1 Astronomy Transformed

The complexities of William Huggins's character and of the scientific era during which he worked are tackled in Barbara J. Becker's new biography *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy*. An academic historian, Becker has spent years poring over Huggins's unpublished correspondence and observing notebooks. She paints a fascinating portrait of the avuncular Huggins, while sorting truth from fiction—or at least from exaggeration—in Huggins's own recollection of events.

Astronomical observation up to the 1840s was a visual art, at first carried out by the unaided eye and later by the telescope and its attendant measuring accessories. The appearance of celestial objects, as best they could be recorded by hand, was subjective: the sum of the observer's perceptive ability and artistic skill. Through the eyepiece, a star is a flickering mote of light, whose breadth has nothing to do with its intrinsic size, but is an artifact of telescopic diffraction and atmospheric turbulence. Early nineteenth-century astronomers could be forgiven for their belief that the incredible remoteness of stars placed knowledge of their physical attributes forever beyond their grasp. Telescopes had given astronomers the capacity to see farther into the cosmos and to magnify what they saw; yet even this empowered human eye was dumb to the revelatory data encoded within the enhanced starlight.

It's no surprise that astronomers of the early nineteenth century applied their considerable energy toward what they considered to be a more productive end: the precise measurement and mathematical reduction of the positions and movements of celestial objects. These observers formed an exclusive club of borderline-compulsive, mostly university-trained perfection-seekers who tried to wring every decimal place of precision from their measurements. Some worked alone, mistrusting anyone but themselves to adequately perform the task; others fashioned small factories of trained assistants to conduct the mind-numbing work. (England's Astronomer Royal John Pond referred to his hirelings as "obedient drudges," living antecedents of the modern electronic computer.)

Professional astronomers reveled in the mathematical complexity of their work and in the clocklike intricacy of their instruments. Their goal was audacious in their own minds, if somewhat baffling in the public's: to precisely fix the starry backdrop against which the rules of Newtonian orbital mechanics might be applied to the wanderings of planets, asteroids and comets. It was the ancients' celestial mapmaking, only writ large and mathematical. Accordingly, speculation about the physical nature of the universe was intriguing, yet pointless, given the dearth of facts. Noted German astronomer Friedrich Wilhelm Bessel, in an 1848 review, told readers that the sole mission of the telescopic observer is "to supply the instructions by which Earth-bound observers can compute the movements of the heavenly bodies. Everything else that one might learn about these bodies—the appearance and constitution of their surfaces, for example—may be worthy of attention, but it is of no real concern to Astronomy" [Becker (2011), p. 13].

Between the 1840s and the 1920s, the very working definition of astronomy changed. For many decades after their respective introductions in the mid-nineteenth century, the camera and the spectroscope were largely shunned by professional astronomers. Few in academia would stake their advancement on a virgin technology outside the professional mainstream. It was hard enough to manipulate eyepieces and a telescope's mechanical workings in the frigid darkness of the observatory; why deal additionally with wet photographic plates or high-voltage gas tubes? Yet a core of capable amateur astronomers proved less averse to such forays into the messy, odorous world of "chemical astronomy." Spurred to supplement the human eye as the traditional window onto the universe, they had no qualms about replacing the direct eye-view of a celestial object with a time-exposure photograph or even a matrix of its spectral lines. Many of these amateurs eagerly allotted large sums of money toward their peculiar avocation. Add personal passion into the mix, and you have the formula for uncommon perseverance and virtual inoculation against discouragement. Basic cosmic questions begged to be answered, a loftier goal, it must have seemed, than adding a decimal place to a star's position.

2 The Professional Amateur

William Huggins rode the crest of this wave of amateur innovators, who together helped remake observational astronomy through technological development. Becker's book opens with synopses of British astronomical practice during the nineteenth century and the concurrent, gradual unfolding of spectroscopic knowledge through Kirchhoff's critical insight in late 1859. She follows with chapters on William Huggins's youth, his lucrative involvement in business, and his subsequent entry into astronomy. The remainder of the book relates, in great detail, the array of observing projects taken on by Huggins during his 40-year career. An ever-present theme is Huggins's lifelong desire to be accepted into the elevated ranks of the academic professionals. Becker makes a compelling case that this impulse might have driven, at least in part, his evident fearlessness in tackling some of astronomy's thorniest problems.

As early as 1862, Huggins embarked on a collaborative program of celestial spectroscopy with his friend and neighbor William Allen Miller, chair of chemistry at King's College London. The year 1862 turns out to be crucial for Huggins's eventual claim of priority, as several researchers in Europe and the US—Giovanni Battista Donati, Pietro Angelo Secchi, and Lewis Morris Rutherfurd—were publishing spectroscopic results around the same time. Significantly, Becker finds no evidence in Huggins's own observing notebooks of such an early or focused effort in this area. His approach to celestial spectroscopy appears to have been more desultory than he later portrayed.

What is known for certain is that in 1864, Huggins and Miller published a report on the visual spectra of some fifty stars, concluding that several stellar line patterns were identical to those of terrestrial elements. Their broad conclusion (echoing that of Fraunhofer many decades earlier) was a rebuke to astronomers who maintained that the starry realm would forever lie beyond the chemist's reach: "[S]tars … are all constructed upon the same plan as our sun, and are composed of matter identical, at least in part, with the materials of our system" [Becker (2011), p. 59]. In this one crisp sentence is a philosophical and practical turning point in humanity's long effort to comprehend the cosmos.

Becker next describes Huggins's early effort to resolve the controversy of the enigmatic nebulae. In a telescope, these faint, diffuse forms exhibit a variety of shapes: clouds, spirals, circular disks. Astronomers disagreed as to whether their glow stems from the collective light of unresolved stars or from the fluorescence of hot, diffuse gas. Huggins visually examined the light of several nebulae and concluded that their distinctive emission-line spectra were unlike the typical absorption-line signature of stars; at least some of these nebulae were wispy clouds of interstellar gas. (Spiral nebulae generally exhibit star-like spectra, and were eventually identified as galaxies external to the Milky Way.) In 1867, Huggins even attempted to measure the line of sight movement of a star from the Doppler shift of its spectral lines, this at a time when the astronomical ramifications of the Doppler effect were as yet unfamiliar to most English scientists.

Huggins's progress is all the more remarkable when one considers that the practical aspects of spectroscopic technology were still being worked out. As Becker makes clear, it's no trivial matter to project a home-brewed comparison spectrum into a telescope so that its lines appear at the proper scale and position alongside a barely discernible celestial spectrum. Huggins stocked his household observatory with the trappings of the Victorian spectroscopist—prisms, batteries, induction coils, Leyden jars, Bunsen burners, chemical powders—until it resembled a Frankenstein's laboratory.

In 1875, with his expert collaborator Miller dead now 5 years, Huggins married Margaret Lindsay Murray, 24 years his junior. Becker asserts convincingly that Margaret rapidly became far more than her own self-described "capital scientific housemaid," but William's full partner in research. Almost immediately, Huggins transformed his spectroscopic research to a photographic basis, evidently taking advantage of Margaret's longtime experience with the camera. (Photography was a rare, but growing, avocation of Victorian-era women.) Within a year, Becker finds, Margaret's handwriting appears in the Tulse Hill observing notebooks, with the occasional telltale first-person "I" reference. Entries are now more detailed and explanatory than before. Eventually, she is listed as co-author with William of their various research papers. Certainly in Huggins's later years, Margaret was the engine that kept the challenging night-shift work going. She was awarded honorary membership in the Royal Astronomical Society in 1903. (Full membership was denied to women until 1915.)

William Huggins died in 1910, late enough to see spectroscopy become an established tool in the arsenal of the observational astronomer. In an interview that year, he summed up his creed in the simplest terms: "Life is work, and work is life" [Becker (2011), p. 300]. Becker reveals how Margaret carefully nurtured her husband's legacy after his death, content to be relegated to a secondary role. Becker's uncut rendition of the Huggins's story shows that this is a Victorian power couple to be celebrated.

3 Conclusions

To bend the Churchillian truism toward the case at hand, "History is written by those who outlive their competitors." William Huggins survived his fellow spectroscopic pioneers, and his memoirs and lectures focus on his own accomplishments, while presenting cursory abstracts of the others'. While Huggins's contributions to the development of what came to be termed *astrophysics* are unassailable, Becker reveals that his retrospective narrative amps up the inerrancy of the quest and brushes away the profusion of footsteps along more convoluted paths of investigation. Hindsight is recast as foresight, trial and error as willful decision making. *Unravelling Starlight* is a science history book that delves deeply into the intricacies of unfolding theories and methods, interpersonal and institutional rivalries, and—at base—the human character. Becker is the historical scholar as detective, and presents this epic tale of scientific achievement not only to entertain but to educate.

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Battling for priority in early astrophysics

Roger Hutchins

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BOOK REVIEW

BATTLING FOR PRIORITY IN EARLY ASTROPHYSICS

Barbara J. Becker, *Unravelling starlight: William and Margaret Huggins and the rise of the new astronomy*. Cambridge University Press, 2011. Pp. xx + 380, £65 (hardback). ISBN 110700229X.

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In 1885 Agnes Clerke's *Popular History of Astronomy* declared William Huggins (1824–1910) to be the founder of stellar spectroscopy. Her judgement endorsed the view of Huggins himself, who fought to establish and maintain his priority in various researches between 1862 and 1908. The view was encapsulated in 'The new astronomy: A personal retrospect', an article that Huggins published in 1897, and it was systematically deployed by Huggins and his wife, determined that this should become the accepted history of the new science.

Dr Barbara Becker did not buy into Huggins's claim that in 1862 he had heard of Gustav Kirchhoff's discovery of the chemical constitution of the Sun and was suddenly empowered 'to lift a veil'. Her 20-year odyssey comparing his very diverse correspondence with the original observatory notebooks resulted in this first scholarly and definitive biography of William and Margaret Huggins.

In 1858 Huggins was a bachelor of limited means, possessing an excellent 8-inch Clark/Cooke refractor but seeking a research area in which to make his mark. In 1862 he commissioned a spectroscope and applied it to starlight. Whereas early foreign contemporaries fortuitously dropped away, Huggins persisted, obtaining more powerful telescopes than his British rivals. With little formal education, how did he achieve expertise and move from the periphery to the core of the London scientific elite amid their egos and controversies?

In January 1862 Huggins's neighbour, William Allan Miller (1817–70), a respected chemist and Fellow of the Royal Society, lectured on the spectra observed by burning minerals in a laboratory and on the potential for chemical analysis of Kirchhoff's solar spectrum. Miller's assistant Henry Roscoe (1833–1915) spoke of founding a 'new stellar chemistry'. Entrepreneurial, clear-sighted and hard-working, Huggins needed chemical knowledge and laboratory expertise to render his research effective and credible. Miller helped present their researches judiciously to the Royal Society. In 1864 their joint paper 'On the spectra of some of the fixed stars' asserted that an observer with the right instruments and skills could discover the true chemical and physical nature of celestial bodies. Huggins next investigated the disputed nature of nebulae, seen by George Stokes, President of the Royal Society, as a 'crisis'. Huggins concluded that emission nebulae were enormous masses of luminous gas or vapour. In 1865 he was elected a Fellow of the Royal Society and in 1866 was awarded the Society's Royal Medal. In those years

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J. Norman Lockyer (1836–1920) began his career with smaller instruments. A clerk, writing and editing scientific articles, he was initially a useful ally but emerged as a competitor. Meanwhile, Huggins began applying his spectroscope and Doppler's principle to determine stellar radial velocity in the line of sight. The work was fraught with difficulties, but, crucially, the Astronomer Royal, George Airy, approved Huggins's early results as 'very important'.

In response to Huggins's need for more light grasp, the Royal Society funded a 15-inch refractor and an 18-inch reflector. But just as Huggins lost Miller to early death in 1870, he and Airy came under attack on the grounds that Huggins was unaccountable, that his monopoly of the telescopes was inequitable, and that physical astronomy should be undertaken at a new national observatory, which Lockyer might direct. A virulent wider debate ensued. Demonstrating effective sole use of the valuable instruments was a responsibility now made acute, and exhausting. Huggins found an ideal solution in his marriage to Margaret Lindsay (1848–1915) in 1871; he was 51 years old, she was 27. She was self-taught and, as a teenager, had made and used a hand-held spectroscope. She became largely responsible for moving their methodology to the forefront of spectroscopic astrophotography, adapting instruments and procedures and analysing data. Between 1882 and 1888 the Hugginses made a considerable effort to photograph the Orion Nebula. But it would be 13 years before William, under extreme pressure from Lockyer's challenges, credited her presence in the Observatory by naming her in a joint paper. By now Lockyer was director of the Solar Physics Observatory in South Kensington, an astrophysical facility funded by a government grant, and had become Huggins's arch-rival.

In June 1897 Huggins was knighted. In the same month the 'New astronomy' article was published, and in 1898 and 1909 the Hugginses included excerpts from it in their books. The construct was almost complete. In 1908 Huggins initiated the transfer of 'his' telescopes to Cambridge's Newall Observatory, a crucial development for Cambridge astrophysics.

After Huggins's death in 1910, Margaret was mortified by two 'errors' in Hugh Newall's obituary of him in *Science Progress*. Despite anguished letters, Newall would not retract. But his obituary for *Monthly Notices of the Royal Astronomical Society* adhered to Huggins's account. Margaret used her influence with Joseph Larmor to ensure her husband's inclusion in the *Dictionary of National Biography* and managed to vet the obituary in *Proceedings of the Royal Society*, which followed Huggins's narrative. She then gave the observatory notebooks to a remote American college and both planned and funded a memorial in St Paul's; her executrix managed to have the design amended to encompass them both.

Dr Becker explains 'The new astronomy' as being composed to erase the clutter of missteps, frustrating reversals and controversies, arguing that the observatory notebooks were incomplete and that Huggins's progress was episodic and dependent upon research collaboration. In 1885 Huggins was deservedly awarded a second Royal Astronomical Society Gold Medal. Astronomical spectroscopy, with the underlying physical theory so tentative, was a high-risk field of research. He was a brilliant pioneer of stellar radial motion, of nebular spectra, of solar prominences, and of the photographic spectra of stars, nebulae and comets. Not the least of Becker's achievements is to reveal the details of Margaret Huggins's long career in astrophysics.

MARGARET AND WILLIAM HUGGINS

Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy. Barbara J. Becker (Cambridge University Press, Cambridge, 2011). Pp. xx + 380. £65. ISBN 978-1-107-00229-6.

In 1897, as the author of this dense biography reminds us, William Huggins then well in his eighties published his own account of the "new astronomy" that three to four decades earlier he had helped to launch. In later studies about the emergence of astrophysics as a new discipline of astronomy, many seemed to forget that Huggins himself had emphasized this was a "personal retrospect". An intellectual companion of William and Margaret Huggins for the past twenty years, Barbara J. Becker certainly has the required credentials to reassess the value of the astronomer's narrative. By focusing narrowly on Huggins's exceptional career as well as his wife's, Becker has produced a book that strikes me as being both extremely ambitious and perhaps excessively modest.

Becker explains her ambition early in her book. To detach herself from conventional perspectives that have relied too much and too uncritically on Huggins's subjective account, Becker turns to the unpublished material. After a life that was both long and full, the astronomer left an impressive but scattered body of papers that Becker over the years has located and carefully examined. The copious correspondence held in various official repositories and a collection of six observatory notebooks now belonging to Wellesley College near Boston have enabled Becker to go far beyond the published record. She aims at showing that far from merely providing an "odd assortment of details and anecdotes" (p. 3), this material may yield an intimate knowledge of the material culture of early astrophysics. Held to her own expectations, Becker is brilliantly successful. She does show, as she had hoped, that scientific "lives are mosaics fashioned out of happenstance and numerous incremental day-to-day decisions rife with clutter and confusion, dead ends and mistakes" (p. 3).

With this rich source material, Becker identifies many points omitted by Huggins from his own history. She shows how the hesitations that are characteristic of science as it is practised hardly appear in Huggins's recollections. She examines with great precision the circumvolutions of the astronomer's research agenda in relation to changing technologies and social circumstances. Her close study of Huggins's careful work to detect the motion of stars using the spectroscope is worthy of the best studies of the genre. Like other historians before her (e.g., A. J. Meadows in his biography of Huggins's sometime rival in astrophysics, Norman Lockyer), Becker underscores the personal and institutional controversies that plagued the early history of astrophysics in Britain and that were, by and large, left aside by the older Huggins.

But Huggins's greatest erasure from history, according to Becker, was his wife, Margaret Lindsay Huggins. One of the great "creative couples" of astronomy, the Huggins indeed worked side by side for twenty-five years. Becker's minute examination of the notebooks they kept provides convincing evidence that Margaret's role in the scientific relationship they forged with one another was close to that of an equal partner — at least in private. By tracking the woman's footprint in the notebooks, published papers and correspondence, Becker draws one of the fullest portraits of the scientist's wife at work that has ever been produced and illuminates the opportunities for a Victorian woman to contribute to science and the limitations imposed on her by society.

We may do no more here than barely scratch the surface of what the reader can take out of this careful study of a businessman-turned-astronomer, of the various aspects of spectroscopy in the second half of the nineteenth century, eclipse expeditions, stellar astronomy, photography of the corona, nature of the nebulae, planets, and the Sun, etc. The book also provides a lively account of the conflicted interactions among the Royal Society, the Royal Astronomical Society, and the Royal Observatory Greenwich, as well as a detailed look at the Devonshire Commission of 1872.

If the Huggins, the material culture of their observatory and the professional networks they built around themselves vividly come to life in this book, Becker may be too timid when it comes to widening her point of view. What enabled amateurs such Huggins and Lockyer to challenge the primary focus of astronomical research, nudging it from a focus on mathematics to experimental physics and chemistry? Does it even make sense, in this case, to speak of "amateurs"? What was special about the circumstances in Britain and later in the United States, compared to Germany, France, Italy, and Sweden, each of which also would play important parts in defining what astrophysics came to be? We hope that someone, perhaps Becker herself, will exploit the voluminous material she has uncovered to produce broader accounts of the rise of astrophysics that one day may rival Huggins's retrospective construction more radically than by just pointing at what he left out of his story.

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Barbara J. Becker. *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy.* xix + 380 pp., illus., bibl., index. Cambridge/New York: Cambridge University Press, 2011. $110 (cloth).

William Huggins was the son of an English linen draper and worked in the family business in London. Although he did not attend university, he cultivated an interest in scientific matters, particularly microscopy and astronomy. By the time he was thirty Huggins was able to sell the business and buy an estate at Tulse Hill in south London. He constructed an observatory there and devoted his life to the study of astronomy. He is regarded as one of the great amateurs in the history of astronomy, a role that was made possible by his ample means, his scientific connections, and the institutional support of the Royal Society.

Fascinated by work on spectroscopy of the German physicist Gustav Kirchoff, Huggins acquired a spectroscope and used it to examine a range of astronomical phenomena. He worked with his neighbor W. Allen Miller, a professor of chemistry at the University of London. Huggins became particularly adept at analyzing the spectra of starlight. This activity involved comparison of stellar spectra with the spectra of substances burned in the observatory as observations were being made. In 1875 Huggins married Margaret Lindsay Murray, a much younger Irish woman who was keenly interested in astronomy. She became his observatory assistant and collaborated with him up to his death thirty-five years later.

An account of William Huggins's life based on an unfinished work by Margaret was published in 1936. *Unravelling Starlight* is the first major biographical study of Huggins by a historian of science. In 1896 Huggins published an essay titled "The New Astronomy"; it is reprinted as an appendix to Barbara Becker's book. In it Huggins presented his researches of the previous forty years as part of a new program of applying chemical physics to astronomy. The 1896 essay was in fact a rather idealized participant report written many years after the events being recounted. A range of motivations and problems spurred Huggins at different points in his career. For example, his first major scientific discovery, the detection in 1865 of emission-line spectra in planetary nebulae, was prompted by some fairly specific developments in contemporary stellar astronomy. In the early 1860s there was a discussion among several observers concerning the variability of nebular objects. This discussion occurred in both astronomical journals and popular magazines that covered scientific subjects.

In 1868 Huggins used small shifts in the spectroscopic lines of the star Sirius to measure its Doppler velocity along the line joining the observer to the star. A mathematical analysis of this phenomenon was communicated by James Clerk Maxwell in a letter to Huggins in 1867. Huggins printed an excerpt from Maxwell's letter along with a detailed account of his observations in an article published in the *Philosophical Transactions*. Becker shows that there were difficulties with Huggins's measurements and interpretation and that his finding was by no means conclusive. Nevertheless, he brought the phenomenon of Doppler velocity shifts to the attention of astronomers and helped to initiate a major area of stellar research.

Becker points out that modern scientific collaboration occurs in the form of hierarchical groups of investigators composed of theorists and instrumentalists; first, second, and third authors; and so on. By contrast, collaboration in the nineteenth century tended much more to involve the coming together of independent and coequal researchers. Becker believes that the modern hierarchical conception of scientific research has colored historians' view of the joint work of William and Margaret Huggins. William is seen as the primary figure, while Margaret is his able but subordinate assistant. Becker's study of unpublished observatory notebooks has led her to conclude that Margaret played a more important scientific role than has been generally recognized. A theme of the couple's joint research from the beginning was the application of photography to the analysis of spectra. Becker documents the interest of Margaret in astronomical photography and suggests that she was the driving force in the application of the new technology to stellar spectroscopy.

Huggins demonstrated the gaseous character of planetary nebulae using spectrum analysis. Looking back on this discovery over thirty years later, he proclaimed that he had solved the problem of the nebulae. Becker accepts this judgment. She refers to Huggins's "landmark discovery" (p. 65) that produced a "seismic shift in thinking about the nebular problem" (p. 71). She is apparently referring to the contemporary perception of Huggins's finding, rather than to its longer-term status in the history of astronomy. In fact, planetary nebulae are rather special and account for only a small percentage of nebular objects. Most of these objects are what were called white nebulae or spiral nebulae and what are known today as galaxies. Huggins believed (erroneously, as it turned out) that nebulae such