

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

UNRAVELLING STARLIGHT

Challenging traditional accounts of the origins of astrophysics, this book presents the first scholarly biography of nineteenth-century English amateur astronomer William Huggins (1824–1910). A pioneer in adapting the spectroscope to new astronomical purposes, William Huggins rose to scientific prominence in London and transformed professional astronomy to become a principal founder of the new science of astrophysics. The author re-examines his life and career, exploring unpublished notebooks, correspondence, and research projects to expose the boldness of this scientific entrepreneur. While Sir William Huggins is the main focus of the book, the involvement of Lady Margaret Lindsay Huggins (1848–1915) in her husband's research is examined, where it may have been previously overlooked or obscured. Written in an engaging style, this book has broad appeal and will be valuable to scientists, students, and to anyone interested in the history of astronomy.

BARBARA BECKER taught history of science at the University of California, Irvine, until her recent retirement. A leading authority on William Huggins, her research interests also include the role of amateurs in the development of nineteenth-century professional astronomy, and the role of controversy in shaping the substance and structure of scientific knowledge.

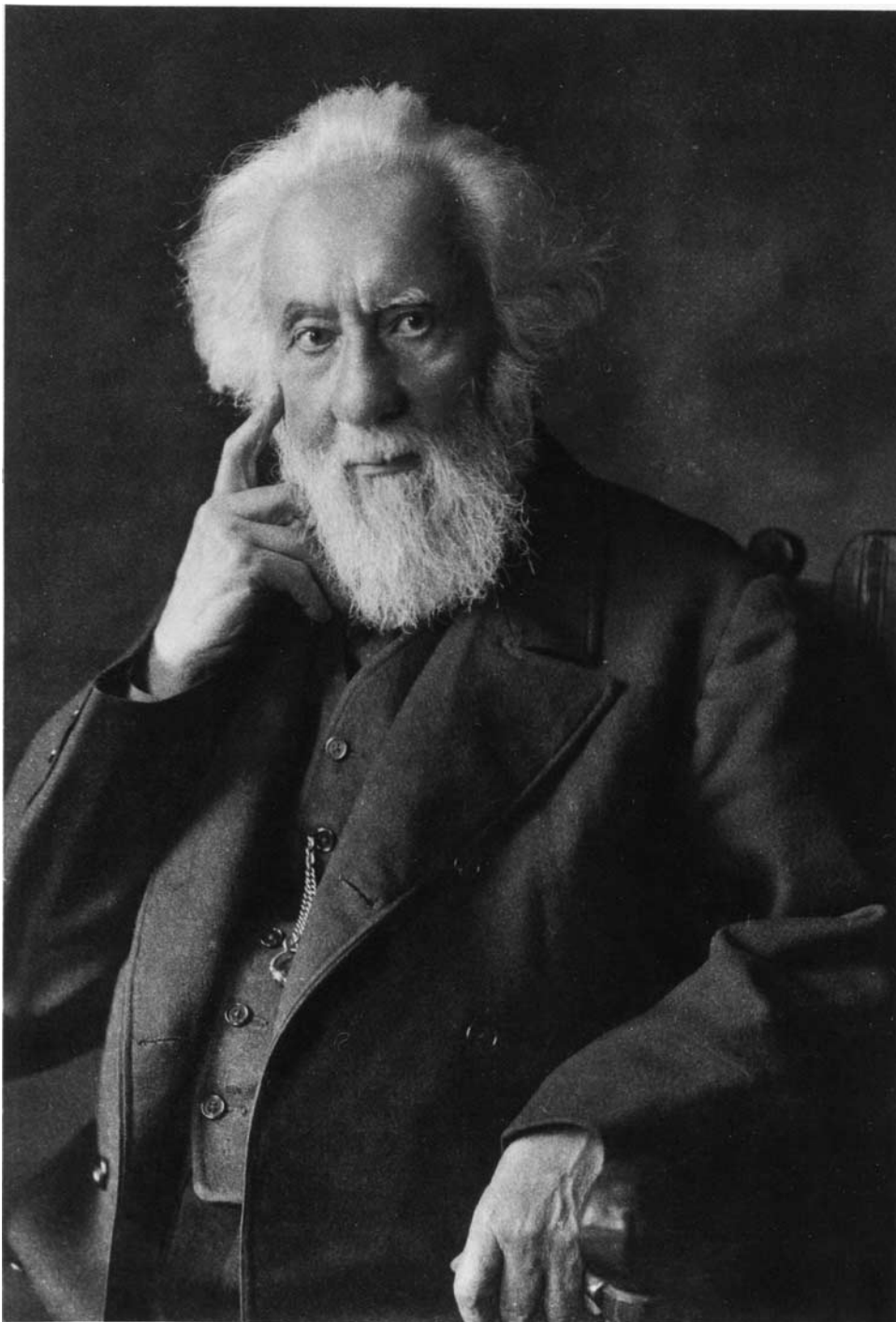
Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)



Sir William Huggins, c. 1905. (PRS 86A)

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

UNRAVELLING STARLIGHT

William and Margaret Huggins and the Rise
of the New Astronomy

BARBARA J. BECKER

University of California, Irvine



Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Tokyo, Mexico City

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9781107002296

© Barbara J. Becker 2011

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2011

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Becker, Barbara J., 1946–

Unravelling starlight : William and Margaret Huggins and the rise of the new astronomy / Barbara J. Becker.
p. cm.

ISBN 978-1-107-00229-6 (hardback)

1. Huggins, William, Sir, 1824–1910. 2. Huggins, Lady, d. 1915. 3. Astronomers – Great Britain – Biography. 4. Astrophysics – History – 19th century. I. Title.

QB35.B43 2011

520.92–dc22

[B]

2010043090

ISBN 978-1-107-00229-6 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New
Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

For Madge

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

Contents

<i>List of illustrations</i>	<i>page xi</i>
<i>Acknowledgements</i>	xiii
<i>List of abbreviations</i>	xvii
1 Introduction	1
1.1 The retrospective narrative	3
1.2 Chapter summaries	5
1.3 A note on the unpublished sources	8
2 ‘The astronomer ... must come to the chemist’	11
2.1 Astronomy in nineteenth-century Britain to 1860	12
2.2 The spectroscope	15
2.3 The puzzle of Fraunhofer’s lines	20
2.4 ‘... something like Qualitative Analysis!’	21
2.5 ‘... the astronomer ... must come to the chemist’	22
3 The young observer	28
3.1 Early life and education	28
3.2 Interest in science	31
3.3 Interest in astronomy	32
3.4 Tulse Hill	33
3.5 An observatory notebook	34
3.6 Developing a research agenda	38
4 ‘A sudden impulse ...’	46
4.1 The Pharmaceutical Society soirée	47
4.2 William Allen Miller	47
4.3 Chemical spectrum analysis	48
4.4 Collaboration	50
4.5 ‘Mr. Huggins ... on the “Stellar Spectrum”’	52
4.6 Spectra of terrestrial metals	54
4.7 ‘On the spectra of some of the fixed stars’	57

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

viii

Contents

5	The riddle of the nebulae	64
5.1	Astronomical questions: summer 1864	65
5.2	Variable nebulae	66
5.3	The ‘interminable wilderness of nebulae’	69
5.4	‘No spectra such as I expected!’	72
5.5	A paper of ‘interest & importance’	75
5.6	Fellowship	76
6	Moving in the inner circle	82
6.1	Cultivating advantageous alliances	82
6.2	Opportunism and eclecticism	84
6.3	The ‘willow leaves’ controversy	84
6.4	The nova in Corona Borealis	86
6.5	The spectra of variable stars	88
6.6	A new star	88
6.7	The red flames	91
6.8	Fireworks and shooting stars	93
6.9	Crater Linné	95
6.10	Thermometric research	96
6.11	Achieving ‘a mark of approval and confidence’	98
7	Stellar motion along the line of sight	104
7.1	The colours of stars	106
7.2	26 May 1864	109
7.3	Stellar motion in the line of sight	111
7.4	Observations	115
7.5	Publication	120
7.6	Response	120
8	A new telescope	126
8.1	‘... discussing the size & plumage of the chicken’	127
8.2	The strains of diversity	134
8.3	The ‘insufficiency of national observatories’	135
8.4	The Devonshire Commission	136
8.5	Dissension in the ranks	141
8.6	The Lockyer factor	143
9	Solar observations	149
9.1	The ‘Great Indian Eclipse’	149
9.2	Viewing the red flames without an eclipse	154
9.3	The eclipse expedition to Oran	156
9.4	Planning the expedition	158
9.5	A registering spectroscope	163
9.6	22 December 1870	164

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

Contents

ix

10 An able assistant	170
10.1 The solitary observer	171
10.2 An able assistant	174
10.3 Margaret Lindsay Murray	176
10.4 Interest in astronomy	176
10.5 The ‘two star-gazers’	178
10.6 Celestial photography	179
10.7 Photography at Tulse Hill	182
11 Photographing the solar corona	192
11.1 The Egyptian eclipse	192
11.2 Photographing the corona	193
11.3 The Caroline Island eclipse	197
11.4 The Riffel expedition	199
11.5 The Bakerian lecture	204
11.6 The Cape Observatory	208
12 A scientific lady	221
12.1 ‘... zeal and perseverance ...’	221
12.2 The Henry Draper Memorial	224
12.3 The ‘meteoritic hypothesis’	226
12.4 The ‘chief nebula line’	229
12.5 ‘I have added the name of Mrs. Huggins ...’	232
12.6 A scientific lady	235
13 Foes and allies	240
13.1 Controversy	240
13.2 American allies	242
13.3 Irreconcilable differences	244
13.4 President of the BAAS	246
13.5 George Ellery Hale	247
13.6 The President’s address	249
13.7 Nova Aurigae	251
13.8 The Yerkes telescope	255
13.9 Photographing the corona without an eclipse	256
13.10 The <i>Astrophysical Journal</i>	258
13.11 The Yerkes Observatory	260
14 The new astronomy	267
14.1 Helium	268
14.2 Accolades and achievements	271
14.3 Radium	275
15 ‘One true mistress’	291
15.1 Passing the baton	292
15.2 The Great Grubb telescope	296

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New
Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

x

Contents

15.3	<i>Scientific Papers</i>	298
15.4	'Life is work, and work is life'	300
15.5	'... guardian of my Dearest's reputation'	301
15.6	'I now withdraw ...'	309
15.7	The new Huggins Observatory	312
15.8	Wellesley College	313
16	Conclusion	322
	<i>Appendix: 'The new astronomy: A personal retrospective'</i>	328
	<i>Bibliography</i>	347
	<i>Index</i>	375

Illustrations

Frontispiece. Sir William Huggins, c. 1905.	<i>page</i> ii
Figure 2.1 William Huggins, c. 1860.	24
Figure 3.1 Title page, Notebook 1.	35
Figure 3.2 Drawings of Mars by Warren De la Rue.	36
Figure 3.3 Observationes Marti by William Huggins.	37
Figure 3.4 Observations of Jupiter by William Huggins.	40
Figure 3.5 Drawings of Jupiter by William Huggins.	41
Figure 4.1 Observations of Saturn by William Huggins.	50
Figure 4.2 Spectroscope of Kirchhoff and Bunsen.	55
Figure 4.3 Improved spectroscope of Kirchhoff and Bunsen.	56
Figure 4.4 William Huggins's chemical spectroscope.	57
Figure 4.5 Interior of the Tulse Hill observatory in the 1860s.	59
Figure 4.6 Spectra of Betelgeuse (α Orionis) and Aldebaran.	60
Figure 5.1 The dark nebula surrounding η Argus [Carinae].	68
Figure 5.2 Plate X. Figs. 1–5, <i>PTRSL</i> , 154 (1864).	74
Figure 6.1 Drawings of sunspots, 23 March 1864, by William Huggins.	85
Figure 6.2 Handheld spectroscope.	93
Figure 6.3a Notebook sketch of thermopile, 24 May 1867, by William Huggins.	97
Figure 6.3b Published drawing of William Huggins's thermopile.	97
Figure 7.1 William Huggins's compound spectroscope.	114
Figure 7.2 Line-of-sight observations, drawings from February 1868 by William Huggins.	116
Figure 7.2a 11 February 1868.	116
Figure 7.2b 24 February 1868.	116
Figure 7.3 Line-of-sight observations, drawings from March 1868 by William Huggins.	118
Figure 7.3a 6 March 1868.	118
Figure 7.3b 10 March 1868.	118
Figure 7.3c 12 March 1868.	118
Figure 7.4 Line-of-sight observations, drawings from March 1868 by William Huggins.	119
Figure 7.4a 18 March 1868.	119
Figure 7.4b 30 March 1868.	119
Figure 7.5 Published line-of-sight diagram.	121

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

xii

List of illustrations

Figure 8.1	New Tulse Hill Observatory.	133
Figure 8.2	Joseph Norman Lockyer (1836–1920).	143
Figure 10.1	Grubb’s automatic spectroscope.	172
Figure 10.2	William Huggins at the star-spectroscope, c. 1904.	174
Figure 10.3	Margaret Lindsay Huggins (1848–1915).	175
Figure 10.4	‘A Photographic Positive’.	183
Figure 10.5	First notebook entries by Margaret Huggins.	184
Figure 10.6	Drawing of a camera by Margaret Huggins.	185
Figure 11.1	William Huggins’s prototype coronagraph.	197
Figure 11.2	Sketches of the solar corona by William Huggins.	200
Figure 11.3	Drawings of the solar corona by William Wesley.	201
Figure 11.4	An improved coronagraph built by Howard Grubb.	209
Figure 12.1a	Spectra of nebulae compared with spectra of hydrogen, cool magnesium and meteorite glow.	227
Figure 12.1b	Comparison of visible magnesium spectrum with that of nebula.	227
Figure 12.2	Drawing of the spectrum of Comet <i>b</i> 1881 by Margaret Huggins.	228
Figure 12.3	Observations of a ‘brilliant aurora’, 4 February 1874, by William Huggins.	234
Figure 15.1	Twin-equatorial telescope.	297

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

Acknowledgements

This book grew out of my dissertation, ‘Eclecticism, Opportunism, and the Evolution of a New Research Agenda: William and Margaret Huggins and the Origins of Astrophysics’ (The Johns Hopkins University, 1993). I still feel the great debt I owe all who helped bring that work to life, particularly to Robert Smith, Peter Hingley and the late Maire Brück, individuals whose encouragement kept me poking around and scribbling over the years.

It was Robert who, back in 1988, first urged me to pursue my interest in investigating William Huggins’s role in the origins of astrophysics. After I completed my graduate work, he continued to serve as mentor and friendly nudge. His scholarship, his breadth and depth of knowledge, his clarity of thought and expression, his incredible memory and attention to detail, his wit, his gentility, and above all his candor and honesty have been an endless source of inspiration for me in my teaching, research and writing.

Peter has taken an avid and active interest in my research from the very beginning. Sitting squarely in the midst of a modern information crossroads, he keeps his attentive and discerning ear to the ground and is generous in keeping scholars abreast of what he hears. Without his enthusiastic intercession on behalf of my manuscript, it would still be filed away out of public view.

I deeply regret being unable to complete this work in time for Maire to see it in print. She was so full of ideas and energy that I foolishly imagined she would always be here. We began our wonderful long-distance conversation in May 1991. The wealth of information she had ready at her fingertips (and floating around on the ends of her cranial neurons) never ceased to amaze me. Her warm generosity in sharing all she knew inspired me to do the same at every opportunity. Whenever I became overwhelmed or disheartened by the task that lay ahead, her letters spurred me on. At each step, she led the way by her own example. It was a joy and a privilege to call her my friend. *Ar dheis Dé go raibh sí.*

Now, over two decades after embarking on my journey, I have a multitude of new debts to declare. Much of my research for the present work was made possible thanks to the kind assistance and dedication of the librarians and staff who both maintain the archival material in their collections and facilitate scholars’ access to them. Throughout the years, each of my many questions and requests received a cheerful response from this lively corps of hard-working individuals who know and understand the value of the treasures they keep. In particular, I would like to thank Peter Hingley (Royal Astronomical Society Library); Adam Perkins and Zoe Rees (Cambridge University Library, Manuscripts Room); Rupert Baker,

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

xiv

Acknowledgements

Joanna Corden and Clara Anderson (Royal Society Library); Dan Lewis (Huntington Library); Gregory Shelton (US Naval Observatory Library); Ruth Rogers and Mariana Oller (Wellesley College Library, Special Collections); Mark Hum (Cambridge University, Institute of Astronomy Library), April Brewer (University of North Carolina, Wilson Library, Rare Book Collection); and Elizabeth Campbell and Melinda McIntosh (University of Massachusetts, Amherst, W. E. B. DuBois Library).

To complement the archival material, my research required direct access to hard-to-locate nineteenth- and early twentieth-century journals, books and other documents. I had already transcribed and photocopied much of what I needed years ago from volumes on the library shelves at Hopkins and the US Naval Observatory, or obtained through interlibrary loan. But the advent of the internet and digitisation of print material brought fully searchable copies of all these resources – and more – to my fingertips whenever I needed them. I (like many other scholars) am extremely grateful for the efforts of everyone responsible for the SAO/NASA Astrophysics Data System (ADS), a Digital Library portal operated by the Smithsonian Astrophysical Observatory (SAO) under a NASA grant and hosted by the High Energy Astrophysics Division of the Harvard-Smithsonian Center for Astrophysics. I also wish to acknowledge my debt to the libraries and other institutions around the globe that have contributed to the growing online availability of books and journals under the aegis of groups like Project Gutenberg, Google Books, Internet Archive and Gallica.

No scholar or her work can thrive in isolation. I am indebted to Helena Pycior, Michael Hoskin, Bernard Lightman, Karl Hufbauer, Michael Crowe, Matt Dowd, David DeVorkin, Peggy Kidwell, Joe Tenn, Wayne Orchiston, Falk Rieß, Tom Williams, the Royal Astronomical Society, the Astronomical Society of the Pacific, the California Academy of Sciences, the Historical Astronomy Division of the American Astronomical Society, the biennial History of Astronomy Workshops and the History of Science Society for the opportunities they have given me to share, discuss and refine my work over the years.

I extend heartfelt thanks to the many people – some friends, others complete strangers – who thoughtfully responded to my queries when my own expertise was inadequate to process the information at hand. John McMahon translated Latin phrases on the title page of William Huggins's first observatory notebook. The page's Hebrew inscription was translated and transliterated by Dan Schroeter. Alan Dehmer's mastery of the art and craft of nineteenth-century photographic techniques and methods enabled me to decipher and interpret barely legible handwritten notes on the subject with greater confidence. Jürgen Teichmann clarified the complex chronology of Joseph von Fraunhofer's employment and responsibilities at the Optical Institute in Benediktbeuern and generously provided me with copies of essential but otherwise inaccessible reference material. Robin Mason and Marilyn Morgan shared valuable information on the casting of Mt Wilson's 100-in glass disc. Art Champagne helped me look at the Hugginses' spectroscopic investigation of the radium glow with modern eyes. David Dewhirst linked me in a very personal way to William Huggins and his Great Grubb telescope through his firsthand account of using the instrument more than a half century ago at Cambridge's Institute of Astronomy.

Space does not permit me to enumerate my many obligations to Jim Bennett, Allan Chapman, Ian Elliott, Owen Gingerich, Ian Glass, the late Owen Hannaway, Peter Harman and Simon Schaffer. Suffice it to say that, without their knowledgeable guidance, kind

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)*Acknowledgements*

xv

assistance and encouragement I would still be wandering in Dante's 'dark wood'. Special thanks to Richard G. French for his personal interest in my work over the years. He is currently overseeing a major renovation of Wellesley College's Whitin Observatory which promises to modernise its instructional operations while restoring its historical beauty. Particularly exciting is the planned restoration and reinstallation of three stained glass windows given to the Observatory by Margaret Huggins in 1914. I am deeply grateful to Dick for his kind permission to use an image of the panel 'Sun with Chromosphere, a Nebula, & other Figures' on the cover of this book. I remember the moment I first saw this extraordinary window. It required quite an effort to remove it from the drawer in the observatory where it had been stored for many years. I had seen a black-and-white photograph of the window, but was totally unprepared for the powerful impact of its vivid colour and exquisite design. It took my breath away.

Most of the illustrations in this book were scanned by me from the volumes in which they originally appeared. One of these figures deserves special mention (see Figure 4.6). It is a reproduction of the frontispiece of William Huggins's booklet *On the Results of Spectrum Analysis Applied to the Heavenly Bodies* (1866) from the library of the late Gerald James Whitrow, FRAS (1912–2000). I was honoured to receive this small book as a gift in 2001 from Professor Whitrow's widow, Magda, through Peter Hingley's thoughtful agency. All of the book's illustrations are original photographs pasted neatly in place. They have faded over the years, of course. Readers wishing to see the details of the spectral map depicted in the frontispiece will find it reproduced more clearly elsewhere (see, for example, Huggins and Miller, *PTRSL* **154**, Plate XI; Huggins and Huggins, *Scientific Papers*, opposite p. 60). I wished to include a copy of this historic image in my own book both as a tribute to Professor Whitrow memory and to express my sincere gratitude to all responsible for the gift.

Other important historic images are included in this book thanks to the efforts and generosity of the following individuals and institutions. A portrait of William Huggins near the beginning of his long career (see Figure 2.1) appears in this volume with the kind permission of the Royal Astronomical Society and Photo Researchers, Inc. Mariana Oller scanned pages from the Tulse Hill Observatory notebooks, portions of which are reproduced in this volume with the kind permission of Wellesley College Library's Special Collections (see Figures 3.1, 3.3, 3.4, 4.1, 6.1, 6.3a, 7.2, 7.3, 7.4, 10.5, 10.6 and 12.3). Gregory Shelton successfully scanned the delicate – and difficult to capture – image of the nebula surrounding η Argus [Carinae] drawn by John Herschel and reproduced on Plate IX of his *Results of Astronomical Observations made ... at the Cape of Good Hope* (1847). The image is reproduced here (see Figure 5.1) courtesy of the US Naval Observatory Library. Imaging Services of the Cambridge University Library scanned an illustrated page from a letter written by William Huggins to George Gabriel Stokes (Add MS 7656.H1168, 2 January 1882). It is reproduced here (see Figure 11.2) by kind permission of the Syndics of Cambridge University Library. Ian Glass generously sent me an historic photograph which shows the coronagraph built by Howard Grubb and used by David Gill at the Cape Observatory to take routine photographs of the solar corona without an eclipse using William Huggins's prescribed method. It is reproduced here (see Figure 11.4) courtesy of the South African Astronomical Observatory.

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

xvi

Acknowledgements

I wish to thank my colleagues and students in the History Department of the University of California, Irvine, for their support and encouragement for my research. It was truly a privilege to be part of such an intellectually stimulating community of scholars. I am particularly grateful to Marc Kanda who kept my access to campus resources active after my retirement. Special thanks to Ingrid Wilkerson and Kim Weiss for sharing their infectious curiosity. Such restless itches (I hope) will never be satisfied.

Finally, a few, albeit inadequate, words of appreciation to my friends and family. Despite her distance, Gillian Wu continues to be an example, an anchor and a cheering fount of unbridled enthusiasm. Louis Carlat's youthful blend of humour and sagacity has kept my thoughts focused and my nose to the grindstone. Thanks to my brother, Pat, for his genealogical research assistance and for helping me locate copies of relevant letters from the Henry Draper papers at the New York Public Library. My daughter, Misha, all the while juggling the demands of motherhood and career, eased my transition to the academic world in Chapel Hill by toting books on arcane subjects from and to the university's various libraries for my use. My son, Aaron, now a father himself, interrupted his busy schedule to venture gamely into the bowels of the microfilm room of UMass, Amherst's DuBois Library to copy pages I had missed in the Hale papers. Their delightful spouses, meanwhile, have come to accept (I think) a pixilated mother-in-law whose head appears to be hopelessly trapped in the nineteenth century. The newest stars in my constellation – granddaughters Olivia, Josephine and Lyra – never cease to energise me and light my path. My best friend and loving husband and I have shared more than four decades together, half of which have been spent co-habiting with the Hugginses! In all that time, Hank has never begrudged their presence. Instead, he has provided me with untiring support for all that I set out to do. Whenever computer glitches halted my progress, he dropped whatever he was doing and calmly came to the rescue. He eagerly stepped into his new role of grandfather to allow me precious time to complete my manuscript. When chapters emerged, his cogent comments and suggestions helped me to see what I had written afresh. Now, as I prepare to resume life in the twenty-first century (already in progress), the doors and windows he has opened make it possible for me to hear the sweet Carolina air resound with strains of bluegrass and children's laughter.

Chapel Hill
North Carolina
12 May 2010

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

Abbreviations

Journals

<i>AA:</i>	<i>Astronomy and Astrophysics</i>
<i>AC:</i>	<i>Annales de Chimie</i>
<i>ACP:</i>	<i>Annales de Chimie et de Physique</i>
<i>ADB:</i>	<i>Australian Dictionary of Biography</i>
<i>AJ:</i>	<i>Astronomical Journal</i>
<i>AJP:</i>	<i>American Journal of Physics</i>
<i>AJS:</i>	<i>American Journal of Science</i>
<i>AJSA:</i>	<i>American Journal of Science and the Arts</i>
<i>AN:</i>	<i>Astronomische Nachrichten</i>
<i>AP:</i>	<i>Annalen der Physik</i>
<i>APC:</i>	<i>Annalen der Physik und Chemie</i>
<i>APJ:</i>	<i>Astrophysical Journal</i>
<i>AR:</i>	<i>Astronomical Register</i>
<i>BJHS:</i>	<i>British Journal for the History of Science</i>
<i>BJP:</i>	<i>British Journal of Photography</i>
<i>CM:</i>	<i>Cornhill Magazine</i>
<i>CR:</i>	<i>Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences</i>
<i>DNB:</i>	<i>Dictionary of National Biography</i>
<i>DSB:</i>	<i>Dictionary of Scientific Biography</i>
<i>EJS:</i>	<i>Edinburgh Journal of Science</i>
<i>EM:</i>	<i>English Mechanic</i>
<i>EPJ:</i>	<i>Edinburgh Philosophical Journal</i>
<i>ER:</i>	<i>Edinburgh Review</i>
<i>IAJ:</i>	<i>Irish Astronomical Journal</i>
<i>IO:</i>	<i>Intellectual Observer</i>
<i>JAD:</i>	<i>Journal of Astronomical Data</i>
<i>JAHH:</i>	<i>Journal of Astronomical History and Heritage</i>
<i>JBAA:</i>	<i>Journal of the British Astronomical Association</i>
<i>JHA:</i>	<i>Journal for the History of Astronomy</i>
<i>JRASC:</i>	<i>Journal of the Royal Astronomical Society of Canada</i>

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)

xviii

List of abbreviations

<i>MLPSM:</i>	<i>Memoirs of the Literary and Philosophical Society of Manchester</i>
<i>MNRAS:</i>	<i>Monthly Notices of the Royal Astronomical Society</i>
<i>NRRSL:</i>	<i>Notes and Records of the Royal Society of London</i>
<i>OBS:</i>	<i>Observatory</i>
<i>PA:</i>	<i>Popular Astronomy</i>
<i>PANSP:</i>	<i>Proceedings of the Academy of Natural Sciences of Philadelphia</i>
<i>PASA:</i>	<i>Proceedings of the Astronomical Society of Australia</i>
<i>PASP:</i>	<i>Publications of the Astronomical Society of the Pacific</i>
<i>PJ:</i>	<i>Pharmaceutical Journal</i>
<i>PM:</i>	<i>Philosophical Magazine</i>
<i>PN:</i>	<i>Photographic News</i>
<i>PRI:</i>	<i>Proceedings of the Royal Institution</i>
<i>PRS:</i>	<i>Proceedings of the Royal Society</i>
<i>PTRSL:</i>	<i>Philosophical Transactions of the Royal Society of London</i>
<i>QJRAS:</i>	<i>Quarterly Journal of the Royal Astronomical Society</i>
<i>QJS:</i>	<i>Quarterly Journal of Science</i>
<i>RBAAS:</i>	<i>Report of the British Association for the Advancement of Science</i>
<i>SM:</i>	<i>Sidereal Messenger</i>
<i>SP:</i>	<i>Science Progress</i>
<i>SS:</i>	<i>Social Studies of Science</i>
<i>ST:</i>	<i>Sky and Telescope</i>
<i>TC:</i>	<i>Technology and Culture</i>
<i>TOS:</i>	<i>Transactions of the Optical Society</i>
<i>TRMSL:</i>	<i>Transactions of the Royal Microscopical Society of London</i>
<i>TRSE:</i>	<i>Transactions of the Royal Society of Edinburgh</i>

Archival sources

CIT:	California Institute of Technology
GEH:	George Ellery Hale papers
CUL:	Cambridge University Library
ERP:	Ernest Rutherford papers
GGS:	George Gabriel Stokes papers
JCM:	James Clerk Maxwell papers
RGO:	Royal Greenwich Observatory
DCL:	Dartmouth College Library
CAY:	Charles Augustus Young papers
HLA:	Huntington Library Archives
HUA:	Harvard University Archives
ECP:	Edward C. Pickering papers
LO:	Lick Observatory
MLSA:	Mary Lea Shane Archives
ESH:	Edward Singleton Holden papers

Cambridge University Press

978-1-107-00229-6 - Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy

Barbara J. Becker

Frontmatter

[More information](#)*List of abbreviations*

xix

NYPL:	New York Public Library
HD:	Henry Draper papers
RASL:	Royal Astronomical Society Library
RSL:	Royal Society Library
AS:	Arthur Schuster papers
JFWH:	John F. W. Herschel papers
JL:	Joseph Larmor papers
SI:	Smithsonian Institution
MAH:	Museum of American History
SAAOA:	South African Astronomical Observatory Archives
DG:	David Gill papers
UEL:	University of Exeter Library
JNL:	Joseph Norman Lockyer papers
WCL/SC:	Wellesley College Library, Special Collections
YUL:	Yale University Library
DPT:	David Peck Todd papers

Organisations/institutions

BAAS:	British Association for the Advancement of Science
IUCSR:	International Union for Co-operation in Solar Research
JEC:	Joint Eclipse Committee
MIT:	Massachusetts Institute of Technology
NAS:	National Academy of Science
RAS:	Royal Astronomical Society
RS:	Royal Society