Night Vision

Drawing on exciting discoveries of the last 40 years, *Night Vision* explores how infrared astronomy, an essential tool for modern astrophysics and cosmology, helps astronomers reveal our universe's most fascinating phenomena – from the birth of stars in dense clouds of gas to black holes and distant colliding galaxies, and the cycle of interstellar dust from its origin in outflows from dying stars to the formation of our solar system. While surveying the progress in infrared observation and theory, astronomer Michael Rowan-Robinson introduces readers to the pioneering scientists and engineers who painstakingly developed infrared astronomy over the past 200 years. Accessible and well illustrated, this comprehensive volume is written for the interested science reader, amateur astronomer, or university student, while researchers in astronomy and the history of science will find Rowan-Robinson's detailed notes and references a valuable resource.

MICHAEL ROWAN-ROBINSON served as Head of Astrophysics at Imperial College London from 1993 to 2007 and as president of the Royal Astronomical Society from 2006 to 2008. He has received several awards for his work in infrared and submillimetre astronomy, including the first Institute of Physics Hoyle Medal in 2008. He worked on the *IRAS*, *ISO*, *Spitzer*, and *Herschel* missions, and was involved in the pioneering submillimetre observations of the 1970s.

Night Vision

Exploring the Infrared Universe

MICHAEL ROWAN-ROBINSON
Imperial College London

CAMBRIDGE UNIVERSITY PRESS

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

Cambridge University Press
32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org
Information on this title: www.cambridge.org/9781107024762

First published 2013

Printed in the United States of America

A catalog record for this publication is available from the British Library.

Library of Congress Cataloging in Publication Data
Rowan-Robinson, Michael.
Night vision : exploring the infrared universe / Michael Rowan-Robinson.
pages cm
Includes bibliographical references and indexes.
ISBN 978-1-107-02476-2
1. Infrared astronomy. I. Title.
QB470.R69 2012
522′.683–dc23 2012005511

ISBN 978-1-107-02476-2 Hardback

For Artie, Amelie, Alice and Lizzie

Contents

Preface *page* ix

1 Introduction 1
2 William Herschel Opens Up the Invisible Universe 15
3 1800–1950: Slow Progress – the Moon, Planets, Bright Stars and the Discovery of Interstellar Dust 23
4 Dying Stars Shrouded in Dust and Stars Being Born: The Emergence of Infrared Astronomy in the 1960s and 1970s 35
5 Birth of Submillimetre Astronomy: Clouds of Dust and Molecules in Our Galaxy 59
6 The Cosmic Microwave Background, Echo of the Big Bang 73
7 The *Infrared Astronomical Satellite* and the Opening Up of Extragalactic Infrared Astronomy: Starbursts and Active Galactic Nuclei 84
8 The *Cosmic Background Explorer* and the Ripples, the *Wilkinson Microwave Anisotropy Probe* and Dark Energy 109
9 Giant Ground-Based Near-Infrared and Submillimetre Telescopes 119
10 The *Infrared Space Observatory* and the *Spitzer Space Telescope*: The Star-Formation History of the Universe 132
11 Our Solar System's Dusty Debris Disk and the Search for Exoplanets 155
12 The Future: Pioneering Space Missions and Giant Ground-Based Telescopes 168

Epilogue 185
Notes 187
Credits for Illustrations 203
Glossary 205
Further Reading 209
Bibliography 211
Name Index 247
Subject Index 250

Color plates follow page 118

Preface

It has been a huge challenge to try to write the whole story of infrared astronomy, from the discovery of infrared radiation from the Sun by William Herschel (1738–1822) in 1800 through to the present day, to the discoveries being made by the space mission named after Herschel. I wanted to make this story accessible to the general reader with some interest in science but no scientific background. At the same time I wanted to make it a full and accurate account. Having lived and worked through the great period of infrared astronomy, from the 1960s to the present, I know many of the major figures whose work is described here, and I wanted to do them justice.

To reach the general reader, I have had to continually simplify the text, moving more complex and detailed material to the notes. Astronomy is a branch of physics, and physics is not an easy subject for someone who has perhaps not even studied it at school. I've provided a glossary of technical terms and tried to keep them to a minimum. The notes and very full bibliography allow the interested reader to explore the full details of a major area of science.

I have written about what I know, the science of infrared astronomy, and haven't attempted to give the full story of the technological developments required to make this science possible. To give some idea of the huge army of people who work to provide the tools for science, an infrared space mission generally involves more than one thousand people in its design and construction. I was drawn into infrared astronomy in the early 1970s by my friend, and colleague at Queen Mary College London, Peter Clegg. It was through him that I became involved in the first infrared space mission, the *Infrared Astronomical Satellite* (*IRAS*), which so transformed infrared astronomy. Consequently, my career in infrared astronomy, and this book, are very much thanks to Peter.

I cannot begin this account of infrared astronomy without mentioning the book by my late friend David Allen, *Infrared, the New Astronomy*, published in 1975.[1] David was a student contemporary of mine, and I met him several times in those days. He and another student friend, Michael Penston, also sadly deceased, ran the student astronomical society. Both became distinguished astronomers; David ended up as a senior figure at the Anglo-Australian Observatory, based in Sydney. He specialized in infrared astronomy and built infrared instruments for the Anglo-Australian Telescope, a 4.2-metre-diameter telescope built jointly by Australia and Britain. Later I found myself chair of the Anglo-Australian Telescope Board, which managed the telescope and observatory, at a time when David was terminally ill with cancer. Shortly before his death, I went with the members of the Board to visit him at his bedside and consult him about the future of the observatory.

Infrared, the New Astronomy is a delightful and idiosyncratic account of the emergence and early days of infrared astronomy. There are dark hints of rivalries and disputes between the early pioneers. This was before the launch of *IRAS*, and there are only the first glimpses of the new astronomy that was emerging. But it is fascinating to read this book to get a very different perspective from the one we have today.

More authoritative reviews of the history of infrared astronomy, and of the early days of modern infrared astronomy, have been given by Frank Low, George Rieke, and Robert Gehrz, and I have used these very freely.[2,3] I also found Malcolm Longair's magnificent survey of the history of modern astronomy, *The Cosmic Century*, essential reading.[4] There have been more than 30 reviews of different aspects of infrared astronomy in the excellent series *Annual Review of Astronomy and Astrophysics*, which I found invaluable.

I'd like to thank several colleagues for supplying material, reading the manuscript, correcting my errors, and making very helpful suggestions: Mike Hauser, Mike Werner, Tom Phillips, George Rieke, Ian Robson, George Helou, Ian McLean, Steve Price, Peter Ade and Matt Griffin. I thank John Herschel-Shorland for showing me his archive of William Herschel material and for letting me use his portrait of William Herschel. The late Peter Hingley was, as always, helpful in locating historical material and images. Several people very kindly played the role of the general reader and helped me towards a more comprehensible book: Stephen Curtis, the late David Marcus, and above all, my wife, Mary.