DETECTION OF LIGHT

THIRD EDITION

The invention and development of advanced methods to detect light underlies much of modern technology. This fully updated and restructured third edition is unique amongst the literature, providing a comprehensive, uniform discussion of a broad range of detection approaches. The material is accessible to a broad range of readers rather than just highly trained specialists, beginning with first principles and developing the relevant physics as it goes. The book emphasizes physical understanding of detector operation, without being a catalog of current examples. It is self-contained but also provides a bridge to more specialized works on specific approaches; each chapter points readers toward the relevant literature. This will provide a broad and lasting understanding of the methods for detecting light that underpin so much of our technology. The book is suitable for advanced undergraduate and graduate students, and will provide a valuable reference for professionals across physics and engineering disciplines.

GEORGE H. RIEKE is Regents Professor of Astronomy and Planetary Sciences at the University of Arizona. He switched from TeV gamma rays to the infrared just in time to enjoy its growth from primitive beginnings, to culminate with the launch of JWST. He has contributed to many scientific and technical topics along the way, gaining the background for this broad-ranging book. His other books include *The Last of the Great Observatories* and *Measuring the Universe*, which won the American Astronomical Society's Chambliss Astronomical Writing Award.

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Preface

My goal in writing this book has been to provide a comprehensive overview of the important technologies for photon detection, with emphasis on the underlying physics. The emphasis is always upon the methods of operation and physical limits to detector performance. Brief mention is sometimes made of the currently achieved performance levels, but only to place the broader physical principles in a practical context. This emphasis has required that the book include a lot of derivations (i.e., equations). I have tried to emphasize physical principles, not rigor, but still the strings of equations may put you off. In fact, Stephen Hawking once said with regard to *A Brief History of Time*: "Someone told me that each equation I included in the book would halve the sales." If I rather expansively make the assumption that every human alive would want to buy this book if it had no equations, I conclude that the Press is likely actually to sell only 10^{-132} copies. Since you are now reading the preface, it seems likely that sales have already exceeded projections. I thank you and am more than willing to overlook your skipping as many equations as you wish. Just roll your eyes, say the incantation "Here he goes again," and move on. In general, I have tried to fill in with prose so the qualitative meaning should be clear. You should view this as a book within a book, that is prose explanations of the principles behind a vast array of photon detectors, with more detailed asides interwoven for convenient access should you want more depth.

It is nearly 30 years since the first edition. The perspective is interesting: for a number of detector types, although there has been great progress in capabilities such as array size, read noise, and quantum efficiency, the physical principles have not changed. However, there are a number of new approaches; for example, the role of superconductivity has grown substantially. In addition, detectors used in the X-ray have evolved away from nuclear physics and more into the realm of the approaches used for lower energy photons (but then some of the nuclear physics detectors have moved a bit in this direction also). I have taken advantage of this evolution to describe X-ray detectors wherever feasible, and have dropped the

subtitle that implied the book stopped at the ultraviolet. Over this time, a number of detector types have also slid into oblivion. Because I did not want this edition to grow unnecessarily, I have dropped cases where it seemed to me that the type had only a minor role and was not historically important. Another consequence of the passage of 30 years of time is that the physics involved has become more specialized and complex, and now even review articles sometimes seem to be written for the well-initiated, not for general consumption. The descriptions in this book should be helpful in translating the contents of such reviews into something more easily understood. Based on the extensive survey of the literature that accompanied preparation of this edition, these goals have led to a unique book. It combines subject matter from many disciplines that usually have little interaction into a unified treatment.

I have restricted the physics assumed in the book very strictly to the level attainable after only a semester or two of college-level physics with calculus. To supplement this minimal background, the first chapter includes an overview of radiometry, the second introduces solid state physics, and superconductivity principles are discussed in the seventh. Although many readers may want to skim this material, it gives others with less preparation a reasonable chance of understanding the rest of the book. Although the required preparation is modest, the subject matter is carried to a reasonably advanced level from the standpoint of the underlying physics. Because the necessary physics is developed within the discussion of detectors, the book should be self-contained for those who are outside a classroom environment. There are many more specialized books and review articles; each chapter ends with a list of possible sources for more information.

I thank Karen Visnovsky and Karen Swarthout for their assistance with the first edition. Illustrations have also been provided by Shiras Manning and Danny Pagano. Any corrections, suggestions, and comments will be received gratefully.