What Does a Black Hole Look Like?

Aaron Zimmerman

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a student to obtain a solid understanding of the physical processes involved in the lightning discharge.

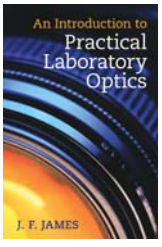
Robert C. Moore
University of Florida
Gainesville

An Introduction to Practical Laboratory Optics

J. F. James
Cambridge U. Press, 2014.
$34.99 paper (196 pp.).
ISBN 978-1-107-68793-6

As someone who has been trained in a state-of-the-art ultrafast optics laboratory, I'd expect a book on practical laboratory optics to discuss how to work with expensive optical components, keep them dust free, and position them for proper use.

I'd also expect an exploration of the physics behind those optical components and how they could be used to construct experimental setups. For example, as part of my experimental-optics training, I had to construct an intensity autocorrelator; the theory of autocorrelation can be found in most nonlinear optics texts.



But particularly for those new to the field, setting up an experiment from components found in a laboratory or purchased from a retailer can be a mystifying challenge. Any book that explains the process is most welcome.

An Introduction to Practical Laboratory Optics by J. F. James is intended as a handbook for professionals and students in experimental optics. However, the focus is not what I expected. Instead of providing hands-on guidance, the book mostly describes the optics of telescopic systems, cameras, and spectrometers.

The early chapters describe lens–mirror systems, the foundation of optics. I enjoyed "Cameras and camera lenses," which explains how the double Gauss lens and other lens systems work. It also presents the technical difficulties of architectural photography and how those difficulties are minimized with the use of "tilt-and-shift" and "rising-front" cameras.

The most interesting concept in the chapter, and one that was new to me, was the notion of a lens's Boys points. Those points are unwanted images—reflections off the lens's surface—and are therefore important to consider when designing optical setups. To accentuate that discussion, the author describes his personal experience designing a focal reducer that was attached to a telescope: He found Boys points from the reducer superimposed with a faint image from the primary mirror of the telescope.

In chapter 12, entitled "Practicalities," the author gives an excellent description of when and how to clean optical elements. He describes the proper technique to clean mounted and unmounted optics but also clearly and correctly emphasizes that cleaning optical elements should be the last resort because any direct contact with optical systems can irreversibly damage them.

The book's handling of mathematics has its positives and negatives. One plus is that the author describes optical concepts clearly and doesn't require readers to perform rigorous mathematical derivations. The book is, therefore, ideal for people with limited mathematical background who want to learn optics.

However, the lack of more rigorous mathematics also prevents me from recommending the book as a reference source for professionals or as a handbook for students. The author does provide some mathematical derivations at the end of the book. There he describes the lens formula, Gaussian beams, the ABCD matrix, optical aberrations, and Fourier optics.

I enjoyed reading the book and learned a few new things. But most of the material can be found in many optics texts. As supplements to James's book, I recommend three in particular—Eugene Hecht's *Optics* (4th edition, Addison-Wesley, 2001), the Optical Society's *Handbook of Optics, Volume IV: Optical Properties of Materials, Nonlinear Optics, Quantum Optics* (3rd edition, McGraw-Hill, 2009), and the *Springer Handbook of Lasers and Optics* (2nd edition, Springer, 2012). For those who seek further reading, James provides a good list of sources.

If you are interested in a book on practical laboratory optics along the lines discussed at the beginning of this review, you may want to browse the self-published ebook *Laboratory Optics: A Practical Guide to Working in an Optics Lab* (2014) by Peter Beyersdorf. Also, don't ignore optical manufacturers, such as Newport Corp and Edmund Optics, which publish excellent practical tutorials on how to handle, clean, and install optical elements.

Robinson Kuis
University of Maryland, Baltimore County
Baltimore

What Does a Black Hole Look Like?

Charles D. Bailyn
Princeton U. Press, 2014. $35.00
(210 pp.). ISBN 978-0-691-14882-3

Early in his book *What Does a Black Hole Look Like?*, Charles Bailyn points out the paradox of the book's subject matter: Since by its very definition a black hole is an object from which no light can escape, how can we see one? And yet, black holes and methods for observing them have a central place in modern astrophysics.

Bailyn's short book unravels the seeming contradiction of "seeing" black holes. Its 10 chapters cover topics ranging from the accretion physics of x-ray binaries to the taxonomy of active galactic nuclei. Recent observations—by modern x-ray telescopes such as NASA's *Chandra X-Ray Observatory* and *NuSTAR* (*Nuclear Spectroscopic Telescope Array*) and the European Space Agency's *XMM-Newton*—have underpinned the many successes and exposed remaining shortcomings in the theories that describe physical processes near black holes. The author's discussion of the open questions and controversies in interpreting data with current theory is timely; it also highlights the opportunity for discoveries still to be made in the field.

What Does a Black Hole Look Like? is the latest in the Princeton Frontiers in Physics series. The stated goal of the series is to have leading specialists provide short introductions to the most exciting areas of physics research today. Indeed, Bailyn is an authority on identifying and measuring the properties of astrophysical black holes; he has authored numerous papers on the subject. He writes clearly and engagingly about observational results and the history of discovery of astrophysical black holes.

The first chapter of the book introduces black holes; the next two cover the bare bones of the theory of accretion physics, radiation, and jets. These early chapters establish the foundation for the remainder of the text. The next six chapters focus on how actual observations are used in conjunction with theory to identify black holes and understand their environment. They cover all types of black holes, from stellar-mass to supermassive black holes. These chapters are the core of the book and offer a lightning introduction to nearly

all aspects of modern research on astrophysical black holes. A short chapter on gravitational waves is a welcome and timely addition to the end of this section of the book, considering that the Advanced LIGO detectors are poised to begin their first observational campaign. The 10th and final chapter focuses on quantum and speculative aspects of black holes. Bailyn's discussion in that chapter of Hawking radiation and primordial black holes is valuable, but there are many popular, entertaining science books that discuss those and other issues in cosmology—predominant among them Stephen Hawking's own still-relevant classic *A Brief History of Time* (Bantam Books, 1988).

Unfortunately, the introductory theory section is relatively weak. That may not be too surprising, since it's unclear who the book's target audience is. The mathematics is kept at a basic undergraduate level, but the physical ideas are often complex. The book is too basic to serve as a topical review for researchers, and the author does not shy away from technical jargon (though he provides a helpful glossary). And some typographical errors early on may confuse the serious student attempting to follow the derivations.

What Does a Black Hole Look Like? would not serve well as a textbook. Although possibly useful as a resource for an undergraduate survey course, the book is too short and too complex to be a main text. Advanced students would be better served by reaching for Bradley Carroll and Dale Ostlie's *An Introduction to Modern Astrophysics* (2nd edition, Addison-Wesley, 2006). Bailyn's book does improve over Carroll and Ostlie's text by incorporating up-to-date observational results and discussing open problems.

The book's best audience would appear to be technically minded nonspecialists who are intrigued by black holes. For them, the author provides a fascinating glimpse into how astronomers study those exotic objects and how the same data set can lead to a variety of interpretations. As an introduction for the growing population of scientifically passionate nonscientists, this brief work is a success.

Aaron Zimmerman
Canadian Institute for Theoretical Astrophysics
Toronto, Canada

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