

## Foundations of Astrophysics

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*Foundations of Astrophysics* provides a contemporary and complete introduction to astrophysics for astronomy and physics majors. With a logical presentation and conceptual and quantitative end-of-chapter problems, the material is accessible to introductory astrophysics students taking a two-semester survey course. Starting with the motions of the solar system and a discussion of the interaction of matter and light, the authors explore the physical nature of objects in the solar system, and the exciting new field of exoplanets. The second half of their text covers stellar, galactic, and extragalactic astronomy, followed by a brief discussion of cosmology. This is a reissue of the original 2010 edition, which has established itself as one of the market-leading astrophysics texts, well known for its clarity and simplicity. It has introduced thousands of physical science students to the breadth of astronomy, and helped prepare them for more advanced studies.

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*For Nancy and Kent*

—B.R.

*For Jan, Evan, Ethan, Erika, Lizzie, Ellyn,  
Christopher, and Aden*

—B.M.P.

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## Preface

This book, like many textbooks, was inspired by teaching a class. The class in question was a two-quarter (5 hours per week) introductory survey course in astrophysics. The reader of this book, like the students in our course, is assumed to have studied a year of calculus (including differential and integral calculus, basic vector calculus, and a smattering of simple differential equations), as well as a year of calculus-based general physics. We assume that the reader has only a remote acquaintance, if any, with quantum physics, special relativity, or linear algebra.

Our fundamental goals for this book are twofold. First, we want to introduce students with a serious interest in physical science to the breadth of astronomy, preparing them for more advanced topical courses in the future. Second, we use astronomical examples to reinforce the physics that the students have already learned. To this end, we use SI (International System) units, which the students have already encountered in general physics class, rather than the cgs (centimeter, gram, second) units that are frequently encountered in the more advanced astronomical literature. Units that are peculiar to astronomers, such as parsecs, magnitudes, solar luminosities, and solar masses, are introduced as needed.

Our organization of the material is, in many respects, quite traditional. We start with the kinematics and dynamics of the solar system; then, after discussing the interaction of matter and light, we proceed to a discussion of the physical nature of objects in the solar system. We conclude our discussion of solar system astronomy with an examination of the solar system as illuminated by the exciting new field of exoplanets. The second half of the book covers stellar, galactic, and extragalactic astronomy, followed by a brief discussion of cosmology.

Our goals for the book, to some extent, dictate the relative emphasis placed on different fields of astronomy. Some particularly rich areas of astronomy, such as stellar populations, globular clusters, and the large-scale structure of the universe, are only briefly touched on. We regret the brevity with which we cover these and other fascinating topics in astronomy. However, we had to balance our desire to make the book of manageable size with our desire to cover thoroughly those topics that enhance understanding of important physical principles (such as blackbody radiation, physics of non-LTE gases, and gravitational accretion).

Our text benefited from criticism by many individuals. Most important, the book was shaped by several classes of undergraduate students at The Ohio State University,

who provided detailed feedback on nearly every aspect of the book. In particular, most end-of-chapter problems in this book have been heavily field-tested; our students never hesitated to point out when a problem was clumsily or ambiguously worded. Many of the remaining end-of-chapter problems are classic problems that appear in somewhat similar form in earlier textbooks. The textbooks from which we have adopted and adapted problems are cited in the Bibliography at the end of the textbook.

We are grateful for reviews of individual chapters by instructors with experience in teaching astrophysics at this level, notably Byron D. Anderson, Phil Armitage, Don Bord, Tereasa Brainerd, David Cohen, John Cowan, Richard A. Crowe, Carsten Denker, George Djorgovski, Stephen Gottesman, Kim Griest, Peter H. Hauschildt, John Huchra, Philip A. Hughes, Steven Kawaler, Jeremy King, Chip Kobulnicky, Donald G. Luttermoser, Kevin MacKay, Michael P. Merilan, Stan Owocki, Eric S. Perlman, Lawrence S. Pinsky, Gary D. Schmidt, James Schombert, Horace Smith, Steven Stahler, Curtis J. Struck, Paula Szkody, Dan Wilkins, Jeff Wilkerson, Richard M. Williamon, Gerard Williger, Vincent Woolf, Kausar Yasmin, and Dennis Zaritsky, as well as a number of anonymous reviewers. We incorporated much of the advice received from these individuals.

We are especially grateful to friends and colleagues at The Ohio State University who provided invaluable assistance. Richard Pogge provided help with both scientific and technical issues. Jessica Orwig prepared many of the figures and tables. Marc Pinsonneault, David Weinberg, and Molly Peebles provided information for figures. Finally, the fact that this is a real book rather than a pile of incoherent notes and scrawled drawings is due to our diligent production team at Pearson Addison-Wesley.