Astronomy (The Textbook)

Book · October 2016

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PREFACE

Welcome to *Astronomy*, an OpenStax resource. This textbook was written to increase student access to high-quality learning materials, maintaining highest standards of academic rigor at little to no cost.

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Format

You can access this textbook for free in web view or PDF through openstax.org, and for a low cost in print.

About *Astronomy*

Astronomy is written in clear non-technical language, with the occasional touch of humor and a wide range of clarifying illustrations. It has many analogies drawn from everyday life to help non-science majors appreciate,

on their own terms, what our modern exploration of the universe is revealing. The book can be used for either a one-semester or two-semester introductory course (bear in mind, you can customize your version and include only those chapters or sections you will be teaching.) It is made available free of charge in electronic form (and low cost in printed form) to students around the world. If you have ever thrown up your hands in despair over the spiraling cost of astronomy textbooks, you owe your students a good look at this one.

Coverage and Scope

Astronomy was written, updated, and reviewed by a broad range of astronomers and astronomy educators in a strong community effort. It is designed to meet scope and sequence requirements of introductory astronomy courses nationwide.

Chapter 1: Science and the Universe: A Brief Tour

Chapter 2: Observing the Sky: The Birth of Astronomy

Chapter 3: Orbits and Gravity

Chapter 4: Earth, Moon, and Sky

Chapter 5: Radiation and Spectra

Chapter 6: Astronomical Instruments

Chapter 7: Other Worlds: An Introduction to the Solar System

Chapter 8: Earth as a Planet

Chapter 9: Cratered Worlds

Chapter 10: Earthlike Planets: Venus and Mars

Chapter 11: The Giant Planets

Chapter 12: Rings, Moons, and Pluto

Chapter 13: Comets and Asteroids: Debris of the Solar System

Chapter 14: Cosmic Samples and the Origin of the Solar System

Chapter 15: The Sun: A Garden-Variety Star

Chapter 16: The Sun: A Nuclear Powerhouse

Chapter 17: Analyzing Starlight

Chapter 18: The Stars: A Celestial Census

Chapter 19: Celestial Distances

Chapter 20: Between the Stars: Gas and Dust in Space

Chapter 21: The Birth of Stars and the Discovery of Planets outside the Solar System

Chapter 22: Stars from Adolescence to Old Age

Chapter 23: The Death of Stars

Chapter 24: Black Holes and Curved Spacetime

Chapter 25: The Milky Way Galaxy

Chapter 26: Galaxies

Chapter 27: Active Galaxies, Quasars, and Supermassive Black Holes

Chapter 28: The Evolution and Distribution of Galaxies

Chapter 29: The Big Bang

Chapter 30: Life in the Universe

Appendix A: How to Study for Your Introductory Astronomy Course

Appendix B: Astronomy Websites, Pictures, and Apps

Appendix C: Scientific Notation

Appendix D: Units Used in Science

Appendix E: Some Useful Constants for Astronomy

Appendix F: Physical and Orbital Data for the Planets

Appendix G: Selected Moons of the Planets

Appendix H: Upcoming Total Eclipses

Appendix I: The Nearest Stars, Brown Dwarfs, and White Dwarfs

Appendix J: The Brightest Twenty Stars

Appendix K: The Chemical Elements

Appendix L: The Constellations

Appendix M: Star Charts and Sky Event Resources

Currency and Accuracy

Astronomy has information and images from the New Horizons exploration of Pluto, the discovery of gravitational waves, the Rosetta Mission to Comet C-G, and many other recent projects in astronomy. The discussion of exoplanets has been updated with recent information—indicating not just individual examples, but trends in what sorts of planets seem to be most common. Black holes receive their own chapter, and the role of supermassive black holes in active galaxies and galaxy evolution is clearly explained. Chapters have been reviewed by subject-matter experts for accuracy and currency.

Flexibility

Because there are many different ways to teach introductory astronomy, we have made the text as flexible as we could. Math examples are shown in separate sections throughout, so that you can leave out the math or require it as you deem best. Each section of a chapter treats a different aspect of the topic being covered; a number of sections could be omitted in shorter overview courses and can be included where you need more depth. And, as we have already discussed, you can customize the book in a variety of ways that have never been possible in traditional textbooks.

Student-Centered Focus

This book is written to help students understand the big picture rather than get lost in random factoids to memorize. The language is accessible and inviting. Helpful diagrams and summary tables review and encapsulate the ideas being covered. Each chapter contains interactive group activities you can assign to help students work in teams and pool their knowledge.

Interactive Online Resources

Interesting "Links to Learning" are scattered throughout the chapters, which direct students to online animations, short videos, or enrichment readings to enhance their learning. Also, the resources listed at the end of each chapter include links to websites and other useful educational videos.

Feature Boxes That Help Students Think outside the Box

A variety of feature boxes within the chapters connect astronomy to the students' other subjects and humanize the face of astronomy by highlighting the lives of the men and women who have been key to its progress. Besides the math examples that we've already mentioned, the boxes include:

Making Connections. This feature connects the chapter topic to students' experiences with other fields, from poetry to engineering, popular culture, and natural disasters.

Voyagers in Astronomy. This feature presents brief and engaging biographies of the people behind historically significant discoveries, as well as emerging research.

Astronomy Basics. This feature explains basic science concepts that we often (incorrectly) assume students know from earlier classes.

Seeing for Yourself. This feature provides practical ways that students can make astronomical observations on their own.

End-of-Chapter Materials to Extend Students' Learning

Chapter Summaries. Summaries give the gist of each section for easy review.

For Further Exploration. This section offers a list of suggested articles, websites, and videos so students can delve into topics of interest, whether for their own learning, for homework, extra credit, or papers.

Review Questions. Review questions allow students to show you (or themselves) how well they understood the chapter.

Thought Questions. Thought questions help students assess their learning by asking for critical reflection on principles or ideas in the chapter.

Figuring For Yourself. Mathematical questions, using only basic algebra and arithmetic, allow students to apply the math principles given in the example boxes throughout the chapter.

Collaborative Group Activities. This section suggests ideas for group discussion, research, or reports.

Beautiful Art Program

Our comprehensive art program is designed to enhance students' understanding of concepts through clear and effective illustrations, diagrams, and photographs. Here are a few examples.

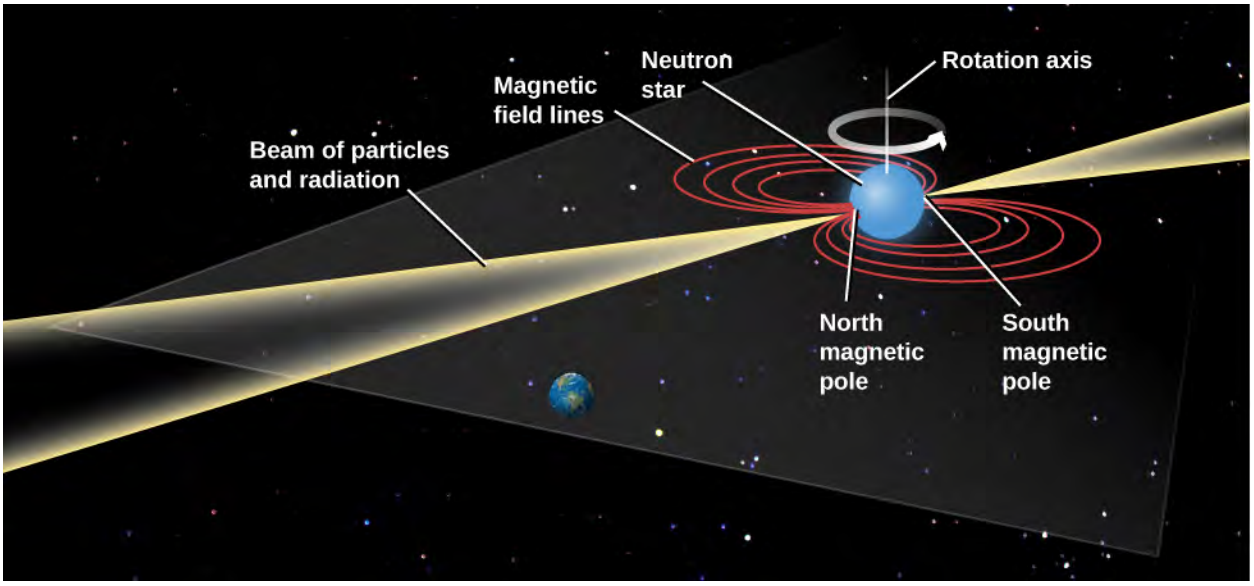

Figure 1. How a Pulsar Beam Sweeps over Earth.

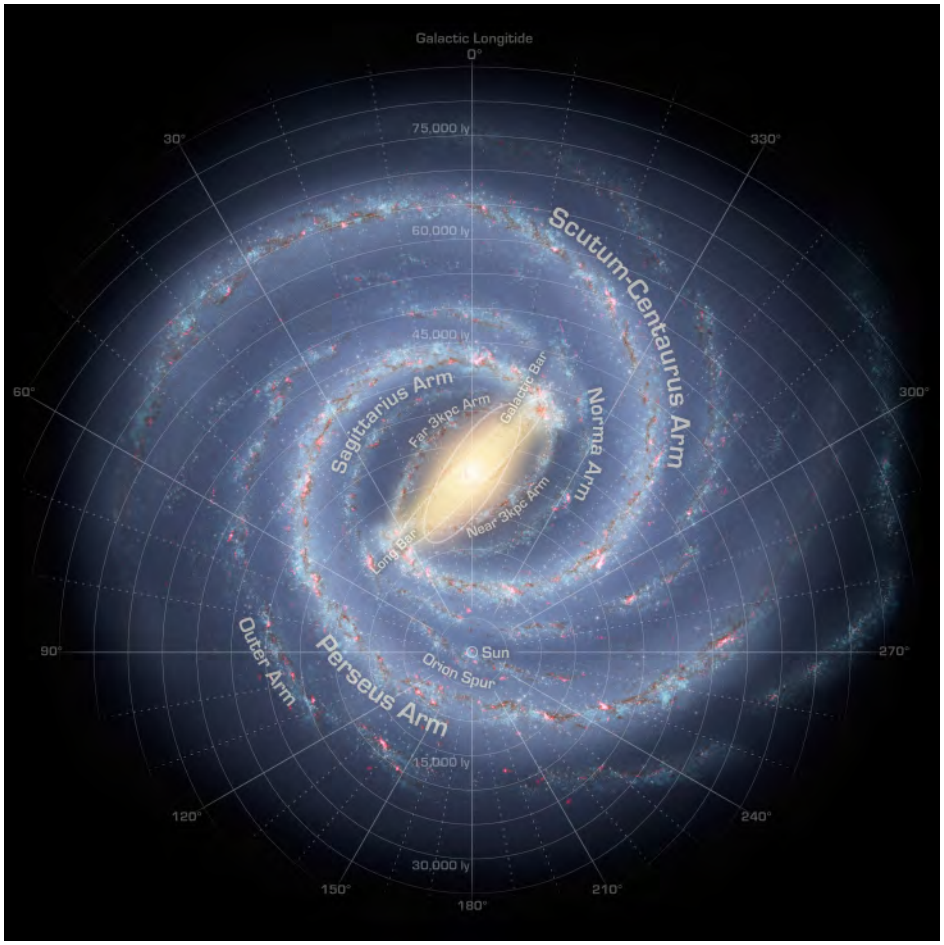

Figure 2. Structure of the Milky Way Galaxy.

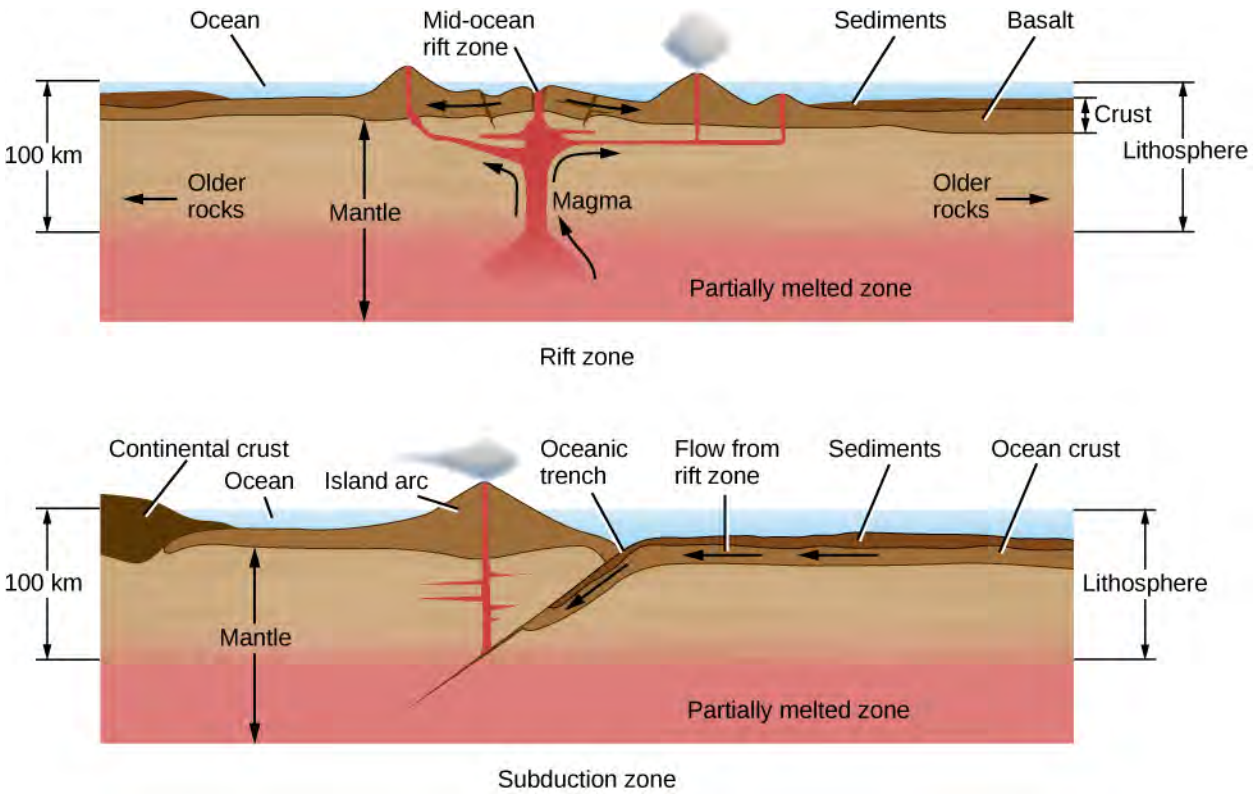

Figure 3. Two Aspects of Plate Tectonics.

Figure 4. Pluto Close Up.

Additional Resources

Student and Instructor Resources

We've compiled additional resources for both students and instructors, including Getting Started Guides, PowerPoint slides, and an instructor answer guide. Instructor resources require a verified instructor account, which can be requested on your openstax.org log-in. Take advantage of these resources to supplement your OpenStax book.

Partner Resources

OpenStax Partners are our allies in the mission to make high-quality learning materials affordable and accessible to students and instructors everywhere. Their tools integrate seamlessly with our OpenStax titles at a low cost. To access the partner resources for your text, visit your book page on openstax.org.

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Andrew Fraknoi, Foothill College

Andrew Fraknoi is Chair of the Astronomy Department at Foothill College and served as the Executive Director of the Astronomical Society of the Pacific from 1978–1992. His work with the society included editing *Mercury* Magazine, *Universe in the Classroom*, and *Astronomy Beat*. He's taught at San Francisco State University, Canada College, and the University of California Extension. He is editor/co-author of *The Universe at Your Fingertips 2.0,* a collection of teaching activities, and co-author of *Solar Science,* a book for middle-school teachers. He was co-author of a syndicated newspaper column on astronomy, and appears regularly on local and national radio. With Sidney Wolff, he was founder of *Astronomy Education Review*. He serves on the Board of Trustees of the SETI Institute and on the Lick Observatory Council. In addition, he has organized six national symposia on teaching introductory astronomy. He received the Klumpke-Roberts Prize of the ASP, the Gemant Award of the American Institute of Physics, and the Faraday Award of the NSTA.

David Morrison, National Aeronautics and Space Administration

David Morrison is a Senior Scientist at NASA Ames Research Center. He received his PhD in astronomy from Harvard, where he was one of Carl Sagan's graduate students. He is a founder of the field of astrobiology and is known for research on small bodies in the solar system. He spent 17 years at University of Hawaii's Institute for Astronomy and the Department of Physics and Astronomy. He was Director of the IRTF at Mauna Kea Observatory. Morrison has held senior NASA positions including Chief of the Ames Space Science Division and founding Director of the Lunar Science Institute. He's been on science teams for the Voyager, Galileo, and Kepler missions. Morrison received NASA Outstanding Leadership Medals and the NASA Exceptional Achievement Medal. He was awarded the AAS Carl Sagan medal and the ASP Klumpke-Roberts prize. Committed to the struggle against pseudoscience, he serves as Contributing Editor of *Skeptical Inquirer* and on the Advisory Council of the National Center for Science Education.

Sidney C. Wolff, National Optical Astronomy Observatories (Emeritus)

After receiving her PhD from the UC Berkeley, Dr. Wolff was involved with the astronomical development of Mauna Kea. In 1984, she became the Director of Kitt Peak National Observatory, and was director of National Optical Astronomy Observatory. Most recently, she led the design and development of the 8.4-meter Large Synoptic Survey Telescope. Dr. Wolff has published over ninety refereed papers on star formation and stellar atmospheres. She has served as President of the AAS and the ASP. Her recently published book, *The Boundless Universe: Astronomy in the New Age of Discovery*, won the 2016 IPPY (Independent Publisher Book Awards) Silver Medal in Science.

All three senior contributing authors have received the Education Prize of the American Astronomical Society and have had an asteroid named after them by the International Astronomical Union. They have worked together on a series of astronomy textbooks over the past two decades.

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