Title: ***Essential Radio Astronomy***
Author: J. Condon, S. Ransom
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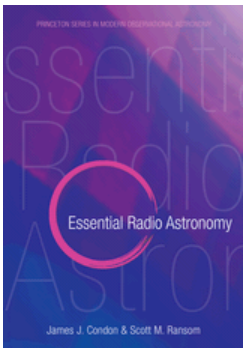
Reviewer: Whitham D. Reeve



This review of ***Essential Radio Astronomy*** is the third and final review in a series of contemporary radio astronomy books. Books in this series previously reviewed were ***Radio Astronomy: An Introduction*** [Joardar] from 2015 and ***Fundamentals of Radio Astronomy: Observational Methods*** [Marr] from 2016. The reviews are at [ReeveRAI] and [ReeveFRA], respectively. Unlike ***Fundamentals of Radio Astronomy: Observational Methods***, the emphasis in the current book is on the types of radiation that may be received from celestial radio sources. One chapter is devoted to radio telescopes and radiometers. This makes the current book a good complement to ***Fundamentals of Radio Astronomy: Observational Methods*** because the latter emphasizes radio telescopes and only briefly discusses radiation types.

Essential Radio Astronomy is a book in the Princeton Series in Modern Observational Astronomy and is based on the National Radio Astronomy Observatory (NRAO) online radio astronomy course with the same name {ERA}. In fact, it is not necessary to purchase this book at all. If readers prefer to not have another hardcover book on their shelves, they can freely download PDF files that have nearly identical content {ASTRO534}; however, the chapters and sections are slightly rearranged and some have different names, and some of the appendices in the hardcover book are not available as PDF files.

The book reviewed here has a slightly informal style but, like the associated online course, can be high-strung in places. It is appropriate for amateur radio astronomers with a strong math and technical background. This should not be a surprise because the book grew out of lecture notes from a radio astronomy course for graduate students. The book itself has no review questions or problems at the end of the chapters as one would expect in a textbook. However, the link above to the PDF files includes access to problem sets and solutions as well as the final exam with solutions.

The chapters are:

Chapter 1	*Introduction*	22 pages
Chapter 2	*Radiation Fundamentals*	41 pages
Chapter 3	*Radio Telescopes and Radiometers*	77 pages
Chapter 4	*Free-Free Radiation*	19 pages
Chapter 5	*Synchrotron Radiation*	48 pages
Chapter 6	*Pulsars*	25 pages
Chapter 7	*Spectral Lines*	44 pages

Also included are eight appendices covering 74 pages: *Fourier Transforms*; *Mathematical Derivations* of the Stefan-Boltzmann law and probability distribution of noise power, among several others; *Special Relativity*;

Wave Propagation in a Plasma; a list of *Essential Equations* (which are keyed to the equation number in previous chapters, a very nice feature); a useful *Constants; Units and Dimensions*; *Symbols and Abbreviations*; and *References and Links*, which is only a few pages long. A separate bibliography is provided with 119 entries.

Essential Radio Astronomy is fairly well illustrated and the illustrations and captions are helpful but brief. There are sixteen color plates in the middle of the book mostly showing celestial radio sources at various wavelengths but some show large parabolic dish antennas. After reading numerous radio astronomy books, both amateur and professional, I have concluded that authors of such books do not believe they have done their jobs unless they include images of the terrestrial emblems of *big bucks radio astronomy* – very large parabolic dish antennas.

Chapter 1, *Introduction*, has an exceedingly short Tour of the Radio Universe, which includes an image of the Sun at 4.8 GHz, a radar image of the Moon at 430 MHz and an all-sky image at 408 MHz. I find it curious that none of the books I have read on radio astronomy include a detailed radio contour map of the sky showing at least the more powerful celestial radio sources as viewed from Earth. Nor do they provide a list of these radio objects. There are 60 objects that exceed 10 janskys (24 radio objects that exceed 40 Jy), a number of them within the capabilities of amateur radio astronomers. Some of these sources are used as calibration or reference sources, so it is not that they are uninteresting. If nothing else, a radio map provides a visual reference for a reader to ponder as they make their way into weak object radio astronomy much like a topographical map provides to a hiker, hunter, surveyor or flier.

Although chapter 1 briefly mentions the Sun in its tour, nothing more is said of it in the book. Also, nothing is said of another very powerful radio source in the Solar System – Jupiter. Perhaps the authors feel there are no potentially important discoveries to be made or perhaps it is because no Nobel Prizes are waiting to be given out for radio astronomy work in our Solar System. Nevertheless, from an electromagnetic radiation perspective (or any perspective for that matter), the Sun and Jupiter are very interesting and far from being fully scientifically understood.

Radiation Fundaments are covered in chapter 2. The discussions of brightness, flux density, black body radiation, emission and absorption, and polarization provide the necessary background for more details in later chapters. The authors use only a few pages to discuss the cosmic microwave background radiation, which is of great interest to radio astronomers and scientists studying cosmology because it potentially provides a lot of information about the early universe. Missing from this book is a discussion of manmade radio frequency interference and the problems it causes. RFI is an important and often limiting component of radio astronomy; however, a form of interference from atmospheric and ground emissions (because it is undesired) is discussed.

Chapter 3, *Radio Telescopes and Radiometers*, provides a decent overview of antenna theory and its application to parabolic dish antennas and feeds. The authors use the physical characteristics of the large professional dish antennas and feeds at Green Bank, West Virginia and the VLA near Socorro, New Mexico to demonstrate applications of the theory. Of interest to many readers is the *radiometer equation* that specifies the relationship between the input noise temperature fluctuations, system noise temperature, system bandwidth and integration time. Chapter 3 shows how to derive both the *ideal* total power radiometer equation and the *practical* radiometer equation that includes receiver gain variation effects.

As indicated above the authors dedicate a chapter to each basic type of radiation: *Free-free radiation* (chapter 4), *Synchrotron radiation* (chapter 5) and *Spectral lines* (chapter 7). A separate chapter (chapter 6) is dedicated to *Pulsars*, which are thought to involve the very strong magnetic fields in very dense, rapidly rotating neutron stars. Free-free radiation also is called Bremsstrahlung radiation, and it involves free electrons that radiate but are not captured during an interaction with an ionized atom or molecule.

The descriptions of the various types of radiation given in chapters 4, 5, 6 and 7 involve a lot of physics and math. ***Essential Radio Astronomy*** includes some actual examples, mostly in the form of back-of-the-envelope and simplified calculations. Of course, the basic assumption in a book like this is that readers have the necessary technical background, but examples always are welcome by readers trying to understanding complex subjects.

No book is perfect, and this one is no exception. The text often refers to a chart or equation given in a previous section or chapter, which is helpful for refreshing one's memory. However, there are a number of times when these references are wrong and I found myself searching for the correct one, sometimes without success. For the sake of other readers I hope the publisher issues errata for this book. Also, in their examples, the authors freely mix centimeter-gram-second (CGS) units of measure with meter-kilogram-seconds (MKS). The current International System of Units (SI) is based on MKS and has been around since the 1960s. Mixing units is cumbersome because of the extra thought and work required to reconcile them, to say nothing of the increased chances for error. The point of an example sometimes gets lost in the tedium of units conversion. However, being able to successfully convert between the unit systems used in older and newer literature is very important to learning about any technical subject, but authors should give their readers a break by sticking to the current system in the main discussion. Calculations using alternate units can be provided parenthetically or in separate paragraphs.

In summary, ***Essential Radio Astronomy*** is an excellent companion to ***Fundamentals of Radio Astronomy: Observational Methods***; together the two provide a broad picture of modern radio astronomy and overlap only in the discussion of radio telescopes. The target audience for ***Essential Radio Astronomy*** includes astronomy graduate students, and its usefulness to amateur radio astronomers is limited to those with a strong math and technical background and the motivation to study a complex subject.

Citations:

[Joardar] Joardar, S. and Claycomb, J., ***Radio Astronomy: An Introduction***, Mercury Learning and Information LLC, 2016 (published 2015, copyrighted 2016)

[Marr] Marr, L., Snell, R., Kurtz, S., ***Fundamentals of Radio Astronomy: Observational Methods***, CRC Press, 2016

[ReeveFRA] Reeve, W., *Review of* ***Fundamentals of Radio Astronomy: Observational Methods***, *Radio Astronomy*, September-October 2016

[ReeveRAI] Reeve, W., Review of ***Radio Astronomy: An Introduction***, *Radio Astronomy*, November-December 2016

Weblinks:

{ASTRO534} http://www.cv.nrao.edu/course/astr534/PDFnew.shtml

(ERA} https://science.nrao.edu/opportunities/courses/era/

Reviewer - Whitham Reeve is a contributing editor for the SARA journal, *Radio Astronomy*. He worked as an engineer and engineering firm owner/operator in the airline and telecommunications industries for more than 40 years and has lived in Anchorage, Alaska his entire life.