BOOKS

At Last! A New Translation of Newton's *Principia*

The *Principia*: Mathematical Principles of Natural Philosophy

Isaac Newton
Translated by I. Bernard Cohen and Anne Whitman, with the assistance of Julia Budenz
Preceded by "A Guide to Newton's *Principia*" by I. Bernard Cohen
U. Calif. P., Berkeley, Calif., 1999. 974 pp. $75.00 hc ($35.00 pb)
ISBN 0-520-08816-6 hc (0-520-08817-4 pb)

Reviewed by Alan E. Shapiro

Virtually everyone who has read Newton's *Principia* in English has read it in the translation by Andrew Motte as revised by Florian Cajori. The Motte–Cajori edition was published by the University of California Press in 1934 and has long been available in paperback. Motte's standard English translation from the Latin appeared in 1729, two years after Newton's death, and by 1934 it was certainly archaic and in need of replacement. For many years, scholars have recognized that Cajori's revision of Motte's translation was inadequate: It was awkward, often inaccurate, and it was based on the second and not the final (third) edition of the *Principia*. I. Bernard Cohen and Anne Whitman have presented us with an entirely new English translation of the *Principia* based, as Newton intended, on his final Latin edition.

The burden of translating the *Principia* into English is akin to undertaking a new translation of the *Bible*. The *Principia* is deservedly one of the most revered scientific works of all time, and people have become accustomed to the old version (although it must be granted that the Motte–Cajori is no King James version). Cohen and Whitman (who died in 1984, after the translation was completed) met the challenge and have produced an excellent, modern translation that is more accurate and easier to read than the Motte–Cajori version.

Some changes of famous passages will no doubt be disturbing to some readers. Newton's first law of motion now reads, according to Cohen and Whitman, "Every body perseveres in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by forces impressed." Compare this with the long-familiar Motte–Cajori version: "Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it." I have no trouble with the change from "continues" to "perseveres"—indeed I approve of it—but "straight forward" for "in a right line" is less satisfying. I would have preferred "in a straight line," but this is a matter of judgment and taste in translation of the sort that can never be fully resolved. Most likely, I will gradually get used to the new version. In the delicate balance between a freer, more readable translation and a more literal one, Cohen and Whitman have generally chosen the latter. I lean toward the former. (One feature that I found lacking is an index that goes beyond the index of names of people cited in the *Principia* itself; there are detailed tables of contents to the *Guide* and the *Principia*, but these are no substitute for a real index in such a densely packed book.)

Having a more reliable and readable translation than Motte–Cajori does not in fact make the *Principia* all that much easier to handle. It was a difficult book when it was first published in 1687, when all scholars were fluent in Latin, and it is still difficult, because of its sophisticated content, Newton's methods, and his style of mathematical exposition. Cohen recognized this problem and has added an introduction that is really another book: "A Guide to Newton's *Principia*."

The Guide is not simply a guide to reading the *Principia,* but is a veritable cornucopia of topics related to that work, such as issues of translation, historical background, conceptual analyses, mathematical methods, and units used. As we would expect of the doyen of Newton scholars, Cohen's judgments and analyses are up to date, fascinating, and useful. Historians rarely deal with the calculations and numerical results in the *Principia*, but Cohen's treatment of these is a welcome and illuminating feature of his Guide.

The heart of the Guide is three chapters devoted to the "structure" of the book—essentially a section-by-section commentary—plus another chapter on "How to Read the *Principia*," which parallels the chapters on the structure but gives step-by-step reconstructions of various key propositions. Those who want to read the *Principia* and work through Newton's proofs will need more guidance than Cohen provides here, and Cohen recognizes this. He includes a generous discussion of other commentaries and guides to the *Principia,* with his recommendations to the reader.

Cohen and Whitman's translation deserves to become the new standard, and the University of California Press has complemented it by producing a handsome volume. With this fine translation and the many other commentaries and guides that have been published recently, it is now much easier for serious readers to discover that magisterial work for themselves.

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Cosmology and Particle Astrophysics

Lars Bergström and Ariel Goobar
Wiley, New York, 1999. 344 pp. $94.95 hc ($49.95 pb)
ISBN 0-471-97041-7 hc (0-471-97042-5 pb)

Physics students find it particularly rewarding when they can reach beyond the routine of "physics education" and get a taste of cutting-edge research. Thus, advanced specialized courses are often our best opportunity to energize our students (both graduate and undergraduate) and motivate them to embrace the challenges we set before them. This is especially so in cosmology, where rapid advances in both theory and experiment are causing many to regard these times as a golden age of cosmology.

Cosmology and Particle Astrophysics by Lars Bergström and Ariel Goobar is intended to support such courses. Targeting their book at advanced undergraduates and beginning graduate students, the authors have correctly identified a gap in the textbook literature. No other text at this level emphasizes the numerous

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connections between cosmology and particle physics. The fact that cosmology is deeply linked with a variety of fields (such as astrophysics, nuclear physics, particle physics, and general relativity) makes it both exciting to study and challenging to teach. The depth and breadth of these links mean that, even when one is teaching very advanced students, compromises must be made between teaching a few things in-depth and surveying a wider range of topics.

Bergström and Goobar have chosen to cover a great range of topics quite briefly, and they make no pretense at providing an in-depth treatment of any topic. The book covers a range similar to that of the classic graduate-level text *The Early Universe* by Edward W. Kolb and Michael S. Turner (Addison Wesley, 1990), with the addition of special relativity, general relativity, quantum field theory, gravitational lensing, the standard model of particle physics, cosmic rays, gamma rays (including gamma-ray bursts), and black holes. All this in about 200 pages fewer than Kolb and Turner used to reach a more advanced audience.

The emphasis of *Cosmology and Particle Astrophysics* is on theory. Many of the end-of-chapter problems involve the derivation of various equations rather than more nitty-gritty astrophysical issues. For example, there is no mention of the cosmic-distance ladder, (although the use of supernovae as standard candles is discussed), but there is a brief discussion of the concept of Majorana mass in quantum field theory. (The solutions to the problems are supposed to be available on the World Wide Web www.physto.se/~lbe/cosm_book, but as of early February 2000, only chapter 1 had appeared.)

In trying to span such a wide range of topics, the authors, I feel, stretch the discussion pretty thin in most places. I am left concerned whether there is enough material to afford the student a foothold. The authors suggest that the book may be useful to astronomy students who are not inclined to take separate courses on field theory, but I am not convinced that such students will find much clarity in the book's rushed discussion of field theory and particle physics. One major disappointment was the quality of the index and cross-references. For example, "microwave background" and "CMBR" in the index cite only minor areas of the text and completely ignore a whole chapter (10 pages) on the subject.

Cosmology and Particle Astrophysics probably works best as a reference work, almost an expanded dictionary, where many things get mentioned but none are discussed at length. I could see it being particularly useful to a student who has had a more focused exposure to cosmology and particle physics and would like to pick up a few things about other topics and develop cross-links in these fields. However, such a student would certainly have to be theoretically inclined to feel comfortable with this book and also be willing not to depend too much on the index.

My advice to colleagues considering teaching from this book is to proceed with caution; look it over carefully. Is it at the right level for your students? Do you see sections that present things in a way you like to teach them? If you use it, you will probably need to supplement it in some way, perhaps by expanding on a selection of topics. Having considered all these issues, you may still find a place for *Cosmology and Particle Astrophysics* in your course. It is certainly a unique and interesting addition to the available texts in this area.

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Howard Aiken: Portrait of a Computer Pioneer

I. Bernard Cohen
MIT Press, Cambridge, Mass., 1999. 329 pp. $34.95 hc ISBN 0-262-03262-7

Makin' Numbers: Howard Aiken and the Computer

Edited by I. Bernard Cohen and Gregory W. Welch
MIT Press, Cambridge, Mass., 1999. 279 pp. $40.00 hc ISBN 0-262-03263-5

Howard Aiken's place in the history of the information revolution is secured: His is the intellect that oversaw the birth of the first modern automatic calculating machine, known both as the Harvard Mark I and the IBM Automatic Sequence Controlled Calculator (ASCC). This nearly 5-ton electromechanical behemoth, conceived in 1937 and placed into operation in 1944, was the first realization of the class of engines, difference and analytical, described by Charles Babbage almost a century earlier. Aiken discovered Babbage's work only after having started on Mark I, and he developed a reverence for Babbage on realizing how similar was their thinking.

I. Bernard Cohen, the Victor S. Thomas Professor Emeritus of the History of Science at Harvard University, is uniquely positioned to document Aiken's contributions. They were colleagues for much of the period, 1935 to 1961, during which Aiken was a faculty member at Harvard. Cohen states that he was motivated to write *Howard Aiken: Portrait of a Computer Pioneer* while editing the companion collection of technical essays and reminiscences on Aiken's accomplishments *Makin' Numbers: Howard Aiken and the Computer*. Although Aiken's work has been well recorded, Cohen felt that the man himself was not adequately represented and that his place in history was undervalued. He conducted a two-day oral-history interview with Aiken a few months before Aiken's death, and he views this *Portrait* as a medium for promulgating Aiken's rich personal history and thinking.

The book focuses on the events surrounding the effort to build, staff, program and promote the use of the Mark I computer, and on some of the problems the machine was used to solve. The machine itself is described in considerable detail, and there are shorter stories of the three later Mark machines.

The Mark I was engineered and built for Harvard by IBM at no cost to the university. The eminent Harvard astronomer Harlow Shapley had introduced Aiken to IBM's Thomas J. Watson Sr, after Aiken had failed to interest a more natural corporate partner, the Monroe Calculating Machine Co, in the project. Cohen documents Aiken's relationships with the IBM technical staff assigned to the project (who actually developed the engineering design with Aiken), with IBM management, with his colleagues, and with the Harvard administration. Cohen also describes, less succinctly than it could be told, the complex situation of two self-centered and uncompromising individuals—Aiken and Watson—and two institutions, one the wealthiest and arguably the most arrogant university in the country and the other on its way to becoming a multibillion dollar enterprise and the leading computer company in the world. The rancor that evolved from the Mark I dedication ceremony in 1944 over where the credit was due left scars that took many years to heal.