

the *Collected Papers of Albert Einstein*, shedding light on such diverse topics as the influence on Einstein of his readings as an adolescent, the impact of Immanuel Kant's philosophy on Einstein, and the genesis of special relativity. It is a very valuable volume for all scholars who are seriously interested in the intellectual development of the young Einstein.

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Light Science: Physics and the Visual Arts

▶ Thomas D. Rossing and Christopher J. Chiaverina
Springer-Verlag, New York, 1999.
\$79.95 (442 pp.).
ISBN 0-387-98827-0

Efforts to make physics courses more meaningful to nonscience majors are continuing by bringing the course work closer to the students' experiences with nature and art. I have taught elective courses in light and color and in sound and music, as well as a required "core" course called, "Exploration of Color." For the light courses, I used *Seeing the Light* by David Falk, Dieter Brill, and David Stork (Harper & Row, 1986). It was somewhat less suitable for the core course. So I was pleased to see that *Light Science* by Thomas D. Rossing and Christopher J. Chiaverina was described in its preface as "intended for students in the visual arts and for readers interested in art." This new book on light, as did Rossing's *The Science of Sound* (2nd ed.; Addison Wesley, 1990), updates existing texts. The book on sound does this with discussions of electronic music and digital techniques, while the light book does it with chapters on advances in holography, computer images, optical recording, communication, and photonics.

The first 8 of the book's 14 chapters deal with the basic physics of light and color which, to a large extent, can be found either slightly more or slightly less mathematically treated in other texts. The structure is similar to that of *The Science of Sound*: text, summary, references, glossary, review questions, and experiments for home, laboratory, and classroom demonstrations. In addition there is an appendix containing about 60 pages of laboratory experiments, which would be useful if a laboratory were to accompany the course.

The frontispiece of the book is denoted as an "ambigram," a word that I could not find in any of my dic-

tionaries. It is in fact a picture with twofold rotational symmetry. This made me think of "topsy turvy" pictures, which look the same upside down as right side up, and of the *Turvy Topsy Contest*, which was run by Arthur Schawlow in the periodical of the Optical Society of America (*Optics News*, February 1975): Produce a slide that can never be right way up! (For winning entries, see *Optics News*, January 1976.) In chapter 13 of their new book, Rossing and Chiaverina return to ambigrams, citing a musical counterpart by Mozart. (There are other well-known examples of musical symmetry, for example, in Igor Stravinsky's *Canticum Sacrum* and Paul Hindemith's *Hin und zurück*.)

Artists use color theory, often in more than an intuitive way. In the 1979 exhibit of the Armand Hammer Collection at the Museum of Fine Arts in Houston, I recall seeing sketches by Paul Gauguin showing his understanding of ray tracing, prisms, and color combinations, with accompanying notes on art theory. Rossing and Chiaverina give a number of well-known applications, as in pointillist, anamorphic, and op art. Sometimes, in turn, artists make a contribution to the science or technology of art: Two musicians, Leopold Godowsky Jr and Leopold Damrosch Mannes invented the Kodachrome process. (But this is a half-truth: They both also had physics degrees!) There are interesting sections in the appendices of *Light Science* on analysis of art materials and conservation and restoration of paintings. These subjects are not treated in the other texts that I consulted.

Holography, the creation of Dennis Gabor, is discussed, from the early use of the laser in this application by Emmett Leith and Juris Upatnieks, and white-light reflection holography by George W. Stroke and Antoine Labeyrie, to present-day TV holography and computer-generated holograms. The basic physics, however, is not explained adequately.

There are a few incorrect statements in the book. The measurement of the speed of light by Olaus Rømer (1644–1710) was not made with use of the Doppler effect; Christian Doppler lived from 1803–1853. Madam Chen-Shiung Wu and Eric Ambler never received the Nobel Prize.

While I can appreciate that authors don't want to scare students with too much mathematics, burying formulas in the text is cosmetic and counterproductive, particularly when these are required in the "exercises" (not called "problems"). Only halfway through the

book do display formulas appear. There are numerous other errors, more or less significant, which I would hope a second edition would correct. Careful editing should eliminate unnecessary repetitions and the introduction of terms without definitions. I can understand the unhappiness of students who encounter such shortcomings. Notwithstanding these criticisms, *Light Science* should serve well its stated readership.

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Bose-Einstein Condensation of Excitons and Biexcitons and Coherent Nonlinear Optics with Excitons

▶ Sviatoslav A. Moskalenko and David W. Snoke
Cambridge U. Press, New York, 2000. \$85.00 (415 pp.).
ISBN 0-521-58099-4

Bose-Einstein Condensation of Excitons and Biexcitons and Coherent Nonlinear Optics with Excitons, by Sviatoslav A. Moskalenko and David W. Snoke, is a most useful text by two physicists each of whom has made substantial contributions to the field of Bose-Einstein condensation (BEC) with excitons, a subject attracting increasing interest at present. My own awareness of this subject goes back to 1993, when I read a paper reporting evidence of BEC in an excitonic gas; the paper caused quite a stir. I was on sabbatical at that time working at NIST, in Gaithersburg, Maryland, and so had time to read it properly. Snoke was a coauthor on the paper, which described a significant development clearly, and a heated debate arose about what had been observed and the potential for future experiments.

Excitons are weakly interacting composite bosons, and one should, therefore, be able to observe BEC in its pure form (BEC is seen in its pure form only in weakly interacting systems) using a gas of excitons. For this and other reasons, there had been an effort to produce a sufficiently dense and cold excitonic gas with which to observe BEC.

That was an exciting time for research in BEC in general, with breakthroughs in the production of atomic condensates soon to occur. (This closely related field has grown

even more rapidly in the intervening years.) There had also been a very lively meeting on BEC in Trento, Italy, in 1993, where the challenges and opportunities for studies of degenerate, weakly interacting gases had been discussed. Moskaleiko and Snoke state, in the introduction to their book, that they had met at this meeting and decided then to write a systematic text on the subject of BEC in excitons and biexcitons. They have succeeded in an admirable fashion, producing an excellent text for graduate students and experienced workers in the field.

The book contains a thorough introduction to all aspects of condensed matter physics, combined with much of the formal theory required to understand a wide range of experiments. Potential readers should, however, equip themselves with a decent background in general quantum field theory in order to make best use of the text. The authors provide accounts of the more specialized theory needed for excitons and their dynamics in the presence of laser driving and relaxation.

The complex relaxation processes seen in exciton systems are described in detail using the Keldysh formalism for nonequilibrium systems. Knowledge of the Keldysh formalism is essential for workers in the field and yet is spread across the literature. The book is, therefore, especially welcome, being a most useful single source for this material as well as a well-written explanation of many important points for the field. The book has a good and rarely encountered balance between formal theory and analysis of specific cases in which experimental data are available.

Excitons behave as composite bosons only at sufficiently low densities. As the density of an excitonic gas is increased, the physics we see becomes that of an electron-hole plasma, an important subject in its own right. The book gives a good account of this link along with a survey of the relevant literature, which helps greatly in placing the subject properly in the context of condensed matter research as a whole.

One of the most interesting phenomena that the text describes is the production of coherent pulses of excitons. One can study the propagation of such pulses and even look at their nonlinear optics. The nonlinear interaction can be used to squeeze the field of the coherent excitons, just as light fields are squeezed by a nonlinear interaction. The ways in which such coherent beams of excitons can be

used in other areas of science and technology are a matter of intense study at present.

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Dynamics of Galaxies

▶ Giuseppe Bertin
Cambridge U. Press, New York,
2000. \$95.00, \$34.95 paper
(414 pp.). ISBN 0-521-47262-8,
ISBN 0-521-47855-3 paper

Giuseppe Bertin's *Dynamics of Galaxies* is an elucidating account of a graduate course given by Bertin over the past two decades. It begins with a brief summary of galaxy morphology and kinematics and continues with a detailed theoretical description of spiral and elliptical galaxies. There is considerable discussion of the rationales for various mathematical approaches, including his own asymptotic and semiempirical models for spiral wave theory. Bertin also points out similarities between galaxy dynamics and other branches of physics such as fluid flow, plasma physics, and electrodynamics. Many of his descriptions are particularly good for beginning graduate students: his chapter on dispersive waves, for example. Each chapter includes thought-provoking questions.

The chapters on spiral density waves, modes, and spiral structure are similar in content and layout to Bertin's monograph with C. C. Lin, *Spiral Structure in Galaxies: A Density Wave Theory* (MIT Press, 1996), with an expanded discussion of the modal theory based on the author's work in the 1980s. Those chapters are the strongest sections of the book, emphasizing Bertin's belief that "a study based on quasi-stationary spiral structure supported by intrinsic global modes gives a natural description of the observed large-scale [spiral] patterns and leads to a successful unified framework for the interpretation of the morphological categories of galaxies." This interpretation partially reflects the limited range of solutions provided by existing analytical theory and symmetry assumptions; a much larger range of processes is thought to occur in real galaxies. For example, numerical models of galaxies, which are dismissed in this book as inherently limited, show a rich collection of additional phenomena that are not discussed here, including Alar Toomre's spiral chaos from local instabilities; bar formation, stability, and dissolution; and tidal interactions. Nonlinear resonances between waves

with different pattern speeds are also not discussed, although some galaxies, particularly those with bars, appear to have these resonances. Also omitted are purely gaseous processes, including star formation and turbulence, which produce realistic structures in numerical models.

The concentration on modal theory to the exclusion of more recent work limits the utility of this book for the general student. Other omissions are noteworthy too: In an observational section on new and future satellites, the most recent members of the great observatories, the Chandra x-ray telescope and the Space Infrared Telescope Facility, are not mentioned. The primary reference given for stellar population synthesis models is Reynier Peletier's 1989 Groningen PhD thesis, but not the more recent and commonly used compendium by Claus Leitherer et al., called "Starburst 99," which is freely available on the Web at <http://coaticook.stsci.edu>. In his section on classification systems, the author discusses the Hubble system and the Luminosity Class, but not the modification by Gerard de Vaucouleurs, which includes the important oval type SAB. The de Vaucouleurs system is the basis for the primary reference tabulation of important galaxy data, the *Third Reference Catalogue of Bright Galaxies*. Bertin also makes comments that might be obscure to someone new to the field, such as his saying that the 7 in an E7 galaxy comes from the observed aspect ratio of 3:1, rather than explaining that it comes from the expression $10(1 - b/a) = 7$ for ratio of axes $b/a = 1/3$.

The other major text on this topic is James Binney and Scott Tremaine's *Galactic Dynamics* (Princeton U. Press, 1987). Bertin's book has more thorough explanations and derivations for much of the mathematics, particularly regarding the modal theory of spiral structure, and it has more recent material in some fields, such as dark matter in elliptical galaxies. But the scope in Binney and Tremaine is more comprehensive and the mathematics better trimmed for easy use. The two books evidently serve different purposes. Binney and Tremaine serve the interests of the general student, whereas Bertin's book is particularly useful for students interested in mathematical methods of galactic dynamics. Bertin's comparisons between galactic dynamics and plasma physics are also innovative and illustrative.

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