BOOKS

The Galaxies In Their Glory; A Thirty-Year Labor of Love

GALAXY IN PROFILE. Galaxy NGC 5746, the brighter member of a pair in the constellation Virgo. For the bulge light to be visible both above and below the near-side dust lane, the line of sight must be within only a few degrees of edge-on. (From *The Carnegie Atlas of Galaxies*, with permission.)

The Carnegie Atlas of Galaxies, Volumes 1 and 2

Allan Sandage and John Bedke
The Carnegie Institution, Washington, D.C., 1994. 731 pp. $92.00 hc ISBN 0-87279-667-1

Reviewed by Sidney van den Bergh

A picture is worth a thousand words. This saying expresses the fact that human beings absorb most information about the world around them from visual images. It is therefore not surprising that our understanding of the realm of galaxies has been strongly influenced by published collections of galaxy photographs. Prior to 1950 the publicly available sample of galaxy images was strongly biased towards pretty, long-armed, high-luminosity spirals and galaxies in rich clusters.

The publication of the Palomar Sky Survey (*National Geographic Society–Palomar Observatory Sky Atlas*, 1954-1958) provided the first unbiased census of galaxies. Inspection of that survey showed that: (1) both the morphology and the mean surface brightness of spiral and irregular galaxies depend on their luminosity; (2) the structure and morphology of galaxies may be modified by their environment; (3) most galaxies in the universe are located in small clusters (like our local group), whereas isolated galaxies and objects in rich clusters are less common; and (4) gravitational interactions between spiral galaxies are more common than had previously been appreciated. Two major shortcomings of the Palomar Sky Survey were that the galaxy images were reproduced at a rather small scale (the typical resolution was two arcseconds), and that the bright central regions of most galaxies were burned out on the images.

The *Carnegie Atlas of Galaxies* overcomes many of these shortcomings by providing large-scale images of 94% of the 1246 brightest galaxies in the sky. A large fraction of the beautiful photographs reproduced in the atlas were obtained by Allen Sandage during a 30-year labor of love using the largest telescopes at the Palomar and Las Campanas Observatories. Most of the images in *The Carnegie Atlas* were obtained with large reflecting telescopes that produced large-scale images having resolutions of one arcsecond or better. The outstanding quality of this atlas owes a great deal to Sandage's perseverance and to his and John Bedke's attention to detail.

It is still too early to say how the publication of this atlas will affect ideas on galaxy morphology and classification. After spending a few weeks studying the images in it, I have the impression that the presence or absence of a nucleus in a galaxy may turn out to be a major factor in determining the morphology of its outer regions. Future generations of astronomers will no doubt learn a great deal by trying to fit this enormous collection of galaxy images into a coherent evolutionary classification scheme.

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Quantum Optics

Daniel F. Walls and Gerard J. Milburn
Springer-Verlag, New York, 1994. 351 pp. $59.95 hc ISBN 0-387-57179-5

Quantum optics has entered a new era. Until the mid-1970s it was sufficient in this field to describe the interaction of light with matter by treating the matter—the atoms—quantum mechanically and the light as a classical wave. In the past 20 years, however, many new effects have surfaced in which the quantization of the radiation field is essential to an understanding of the phenomenon.

For example, Leonard Mandel's group at the University of Rochester, studying the resonance fluorescence from an atom, confirmed the earlier calculations by Howard Carmichael and Daniel Walls showing that light emitted by a driven atom is antibunched. In this circumstance, light shows its granular structure, that is, its quantum nature, by arriving not in bunches but in a more regulated manner.

Another quantum effect elucidated during the last 20 years is the phenomenon of squeezing. Here the fluctuations of the light field are suppressed in one variable at the expense of enhanced fluctuations in the conjugate variable. In the mid-1980s, various groups developed new light sources that emit such squeezed light, which is of ultimate importance in the context of gravitational-wave detection and communication science.

Daniel Walls and his quantum-optics school in New Zealand have always been at the forefront of this hunt for the quantum nature of light; his name is associated with many of the phenomena that define the field. In *Quantum Optics*, Walls, together with Gerard Milburn, has now summarized the contributions of the New Zealand school. The book acknowledges the new era in quantum optics by starting out with the quantization of the electromagnetic field. But as early as the first chapter, Walls and Milburn discuss such novel topics of current research as the properties of squeezed states and the phase operator. Whereas the classic textbooks on quantum optics, such as *Elements of Quantum Optics* by Pierre Meystre and Murray Sargent (Springer, 1991), and *Laser Physics* by Murray Sargent III, Marlan 0. Scully and Willis Lamb Jr. (Addison Wesley, 1987), devote most of their attention to semiclassical quantum optics, *Quantum Optics* is dedicated entirely to the study of the interaction of matter with quantized light.

After a review of the coherence properties and representations of the electromagnetic field, *Quantum Optics* discusses areas to which the Walls school has made substantial contributions. There is a detailed explanation of the generation of squeezed light by a parametric oscillator and by second harmonic, as well as twin beam generations. The authors also present the quantum theory of resonance fluorescence, Bell's inequalities in quantum optics, quantum nondemolition measurements and decoherence in the measurement process. The book concludes with an introduction to the most current field, atom optics, in which the wave nature of the center-of-mass motion of atoms allows for atom interferometers and manifests itself in the diffraction and focusing of atoms from a standing light field. Experimental results accompany the theoretical discussions of these topics in all chapters.

Quantum Optics is written by two leading experts, and it includes topics from the cutting edge of this field. It therefore is at a very advanced level. The book should be recommended reading for graduate-level courses, and it will serve as an extremely valuable reference book for any theoretical or experimental researcher in quantum optics.

There are some draw-backs, however. For instance, in various chapters the equations have become mixed up. Often the reader is referred back to an equation that has nothing to do with the question at hand. Moreover, the notation sometimes changes within a chapter. For example, in chapter 10 the subscripts on the Pauli spin matrices become superscripts in another subsection. Although these are minor details, one should be aware of them so as not to become confused. These minor faults could easily be fixed in a second edition, and they do not detract from the overall goal of the book, which is to provide the reader with an up-to-date and thorough representation of modern quantum optics. In this it succeeds, and I am convinced that *Quantum Optics* will become a standard reference book and will play an important role in the teaching of this field.

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The Observational Foundations of Physics

Alan Cook

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Alan Cook is a physicist of distinction who has played an important part in developing the present high level of precision measurements and standards. In *The Observational Foundations of Physics* he attempts "to unravel some ways in which the practice of physics determines the form and contents of physics and physical theory" and to ascertain "how far and in what ways the formal structure of theoretical physics is determined by the observations it is possible to make of nature." He also asks why mathematics is successful in describing and predicting the results of observations. These are important and difficult questions. Their discussion involves concepts and arguments that are hard to make precise, so their acceptance necessarily involves subjective factors.

I must confess that I find much of the book's reasoning unconvincing. This may be my fault, not that of the book, but the arguments do contain a large number of errors in physics. Space allows me to quote only a few examples. The author argues, for instance, that in many cases physical phenomena and their mathematical description are representations of a symmetry group, and he cites the structures of molecules and crystals, for which he declares, "the relative positions of all particles are known from the space group." In fact, this is true only for Bravais lattices. If it were generally true, crystallographers would be wasting their time.

Then, in discussing the resonance condition involved in the determination of the frequency standard, this relationship is said to demonstrate that the wave function of any stationary atomic state has an exponential time dependence. The argument proves, in fact, only that the *ratio* between the wave functions of any two states varies exponentially in time. The author