graduate student with the methodology and the principal results to date.

The particular merit of the book lies in excellent summaries of the state of the art and comment on controversies and shortcomings. An example is the treatment of planetesimal formation, a problem that was believed to have its essential solution in the scenario of gravitational instability leading to settling of dust on the central plane, proposed by Safranov in 1969 and Goldreich and Ward in 1973. Recent theoretical considerations (chapter 6.4) highlight the difficulties with this model in the presence of turbulence; even a low degree of turbulence would make the gravitational instability mechanism inoperative.

Vital new information has been obtained since the book was written. Evidence has been presented for the presence of preserved interstellar grains of silicon carbide in carbonaceous chondrites. The long-standing controversy over model predictions of early solar nebula temperature as compared to those based on meteorite evidence seems to be under resolution. It has recently been shown that in certain nebular models high temperatures (~1500K) can result in the inner nebula; these are necessitated by the meteoritic evidence. In spite of such advances, the book should have a useful life of at least a decade.

I have asked myself, however, whether after reading this book I would have chosen meteoritics for my graduate studies. I feel that I would have been scared by the complexity of the field and the range of experimental and analytical approaches it now requires. Moreover, an outsider to the field attempting to use this book to learn what the meteorites tell about the early solar system would have to read through most of it, pick out the bits of information deduced and the methods used, and synthesize the data himself or herself. This could be a formidable task. Considerable help and cautionary notes would, however, be provided by the chapters "Boundary conditions for the origin of the solar system" and "Future directions in meteoritic research."

It is my opinion that the book is an invaluable contribution to our knowledge of the subject, presented largely without bias in interpretation of data, and it upholds the high tradition of editing and publishing style set by the Arizona Space Science Series. As for shortcomings, I would pick on two things: it is weak on linkage of meteorite data with observational data on star formation and evolution of young stars, and it is too voluminous. For example, the groups of papers on secondary processing and chondrules take up over 200 pages. One can more easily justify the two other rather lengthy sections on the chemistry of chondrites and the early solar system and on primitive material surviving in chondrites, but even these could have been shorter. The editors' coordination of so much material is a miracle by any standard, however. A great deal of work remains to be done in the study of the early solar system, and further success will emerge only through close coordination with astrophysicists. This is bound to happen in the coming decades with discoveries of young stellar systems with circumstellar material and probable protostellar disks and observations on their formation and evolution.

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A Nearby Star

Astrophysics of the Sun. HAROLD ZIRIN. Cambridge University Press, New York, 1988. x, 433 pp., illus. $49.50; paper, $22.95.

Covering all fields of solar physics in one book is a formidable task by any standard, and in *Astrophysics of the Sun*, a successor to his *The Solar Atmosphere* (1966), Harold Zirin has undertaken just such a grand effort.

In chapter 1 ("Looking at the sun"), Zirin gives an overview of solar physics. In the next chapter, "Observing the sun," he goes about telling the story of Caltech site selection for the Big Bear Solar Observatory and gives persuasive reasons for establishing solar observatories near lakes (examples: Big Bear and Udaipur in India) or oceans (Hawaii). He also describes various optical telescopes—spectrographs and spectroheliographs—and gives a brief account of the National Radio Astronomy Observatory Very Large Array, which has been used fruitfully for solar work during the last solar maximum.

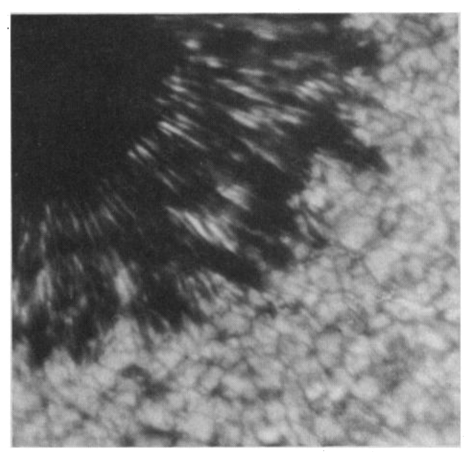
Chapters 3, 4, and 5 discuss plasmas in magnetic fields, interpretation of radiation, and atomic spectra. These chapters, which as Zirin notes are very similar to those in his earlier book, are the most basic from the point of view of learning basic solar physics, and astrophysics in general.

Chapter 6 discusses interior and photosphere, including solar models, the solar neutrino problem, solar rotation and oscillations, and helioseismology. The progress of research in the latter two areas has been so rapid that the discussion of them will have to be updated rather quickly. Excellent phenomenological descriptions of granulation, supergranulation and network structure, and the videomagnetogram observations of dipoles of opposite polarity in and around the network are accompanied by excellent pictures (VMG and other) from Big Bear. The author also discusses the use of the 12-micron line for measuring weak magnetic fields, for example from plage regions, and the measurements of the solar constant by ACRIM aboard the Solar Maximum Mission spacecraft.

Chapter 7 is on the chromosphere. This is a fairly good description of diverse phenomena seen primarily in Hα—spicules, plages, fibrils, and the like—and the nature and origin of spicules are discussed. Observations of spicules in the ultraviolet and extreme ultraviolet suggest that the old idea of the chromosphere being produced by back-conduction from the corona is not valid. The author discusses radio (millimeter) observations but does not give a coherent interpretation of them in the light of our knowledge of the chromospheric structure from observations in other spectral domains. Finally, the chromospheres of other stars, binaries and close binaries such as RS CVn stars, are briefly discussed.

Chapter 8 deals with the corona. Most of the material here comes from the author's earlier book except for the treatment of two important items, coronal holes and coronal mass ejection events, and some elementary description of radio observations of the quiet corona and active regions. The discussion of coronal holes is reasonably complete, the discussion of mass ejection less so.

The next two chapters discuss prominences and solar activity. The discussion of prominences is really an update of Zirin's earlier discussion of the subject, including a great deal of discussion of the structure of



"The area around a sunspot photographed at Big Bear by B. LaBonte. Kodak S0424, a very high contrast, almost grainless emulsion was used. The granulation is unchanged up to the boundary of the spot. This picture has been dodged to show both spot and photosphere." [From *Astrophysics of the Sun*; Big Bear Solar Observatory]

"The great 'sea horse' flare of Aug. 7 1972, taken at $H\alpha$—0.5 Å." [From *Astrophysics of the Sun*; Big Bear Solar Observatory and Zirin and Tanaka (1973)]

sunspots and their immediate vicinity. I am disappointed that there is practically no discussion of radio emission from sunspot-associated regions, especially since the microwave structure of such regions led to the development of the gyroresonance absorption interpretation of the slowly varying component.

Chapter 11, on solar flares, is quite detailed, clearly reflecting the author's expertise. The author describes step by step various facets of the flare phenomenon; spectacular pictures of flares in $H\alpha$ are provided, white light flares are discussed in reasonable detail, and the normal classification of flares as well as the classification based upon HINOTORI x-ray flares is given; flares in gamma-rays (both continuum and lines) and hard x-rays (imaging and non-imaging spectrometer data) are discussed. In the radio domain, microwave spectra and associated theoretical interpretations are provided in some detail; meter-wave observations are discussed minimally, and the discussion is not up to date. Overall this is a good chapter; from it a serious student will get a good flavor of flare physics.

As a whole I find the book to be quite good. The author has covered practically all aspects of solar physics, though I do not think radio observations receive adequate treatment. There are some typographical errors, and some references cited in the text are missing from the bibliography. The book is intended as a textbook for graduate courses in solar physics, but for that purpose it will need to be supplemented by reading material, on, for instance, radio observations and coronal mass ejection events.

In the preface Zirin comments on solar physics research in general and his participation in it. As he laments, university-based solar research has dwindled, and faculty positions for solar physicists are almost nonexistent. Solar research in the United States is coming to be confined almost entirely to the national centers and federal laboratories. Every university-operated radio facility but one has disappeared for lack of funding. To a large extent, the solar physicists, who for too long have been interested only in their own subdisciplines, are to be blamed for this situation. Solar radio astronomy has specially suffered for that reason. For example, the Clark Lake Radio Observatory—a unique and powerful radio facility for observing the Sun—died because of lack of support from non-radio solar physicists, leaving a void in solar physics research that cannot readily be filled. And if solar physics is not done in the universities who will train our graduate students in solar physics? As it is now, a student gets a Ph.D. in a field such as cosmology or extragalactic astronomy and comes to solar physics, often with a contractor (a "beltway bandit"), only on failing to find a job in his or her field. This is clearly not the best way to be training solar physicists, and universities must be made to see that they have a responsibility here.

I recommend the book to all solar physicists, potential solar physicists, and the chairmen of the many astronomy departments where astronomy starts beyond the solar system: they could profitably use it in starting graduate courses in solar physics.

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High-Tech Astronomy

Observational Astrophysics. PIERRE LÉNA. Springer-Verlag, New York, 1988. xii, 328 pp., illus. $54. Astronomy and Astrophysics Library. Translated from the French edition (Paris, 1986) by A. R. King.

For much of the past century the primary tool of the astronomer was a photographic plate exposed through a large optical telescope. The observer sat in total darkness peering through an eyepiece, guiding the telescope for hours with the touch of a surgeon on the controls. Although astronomical photography still has its uses, it receives scant attention in this up-to-date description of modern *Observational Astrophysics*. Instead, we learn about solid-state detectors, bolometers cooled below 1 degree Kelvin, laser-driven heterodyne mixers, spark chambers, and superconducting grains. Some of these detect visible photons with a sensitivity increased by orders of magnitude over the venerable photographic emulsion. But the more striking technology-driven advance of the past several decades has been the opening of the entire electromagnetic spectrum to astronomical scrutiny. On the ground, vast interferometric arrays of radio telescopes probe the cores of quasars with milliarcsecond resolution. Orbiting satellites, unencumbered by the obscuring mantle of Earth's atmosphere, can record images of previously unimagined cosmic phenomena at infrared, ultraviolet, x-ray, and gamma-ray wavelengths. The neutrino burst from the nearby supernova explosion, which triggered underground particle-physics detectors in 1987, also sparked renewed enthusiasm that even this elusive messenger can be used to study astrophysical processes.

Roughly half of *Observational Astrophysics* is devoted to these new detectors and how they record the feeble rain of cosmic radiation that is our link to the rest of the universe. The descriptions, necessarily somewhat brief, are sufficiently detailed and well illustrated to inform the reader about the internal workings of each detector and what it is good for. Many useful graphs, typically with log-log scales that span several decades, compare the capabilities of alternative instrumentation. These chapters are organized by function, such as imaging or spectroscopy. Although this approach is no less contrived than a division by wavelength, it does represent the new "panchromatic" trend in astrophysics: modern observers rarely limit themselves to any single waveband now that the full spectrum is at their disposal.

Some of the other chapters are less well focused. The sections on measurement theory and signal processing are more than is required to establish notation but insufficient to educate the uninitiated. The discussion of observational methods is also quite limited. This is not a handbook for observers. It is a broader text and reference work for students, active researchers, or anyone who wants a detailed look at the tools of modern astronomy. I could wish for a more complete index to further enhance its utility.

In sharp contrast to their predecessors, observers at a modern ground-based facility sit at computer terminals well removed from the instrumentation. The gap is even more extreme in space astronomy, which will undergo a renaissance with the launch of the Hubble Space Telescope later this year. Though hardly a substitute for hands-on experience, this book can inform contemporary observers about the ingenious variety of those remote detectors that feed their terminals with images and spectra of the cosmos.

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