group theory traditionally used by physicists, and might also be useful.

ROBERT HERMANN
Boston University
Boston, Massachusetts

From the Black Hole to the Infinite Universe

D. Goldsmith, D. Levy
330 pp. Holden-Day, San Francisco, 1974. $6.95

The approach of this paperback book, intertwining a science fiction story with textual material, is interesting, but often the connection between the two is artificial. For example, in the science-fiction part of chapter 8, "Lumps of Matter," space hero Cyril Zaki happens to reminisce about the school classes he had muddled through with formulas such as "PeeVee equals Arty" and then later the chapter describes the bulk properties of gases. Also, the fifteen chapters themselves do not follow an obvious order; each appears to be a nearly self-contained description of one selected astrophysical phenomenon or concept.

The authors, D. Goldsmith and D. Levy, have keen insight, and a number of their descriptions (such as presenting the Doppler shift in terms of the photon's energy) were very enlightening. The figures and captions, with a casual style, are generally good and informative although sometimes misleading. The Hertzsprung-Russell diagram, plotted with temperature increasing toward the right, may be a logical manner of presenting the information, but it is one of a kind because the convention in astronomy and astrophysics is always to have temperature increase toward the left. Two colleagues to whom I showed this figure immediately remarked "Hey, that must be Goldsmith's book!" He was considered the most likely astronomer to ignore the traditions of the field.

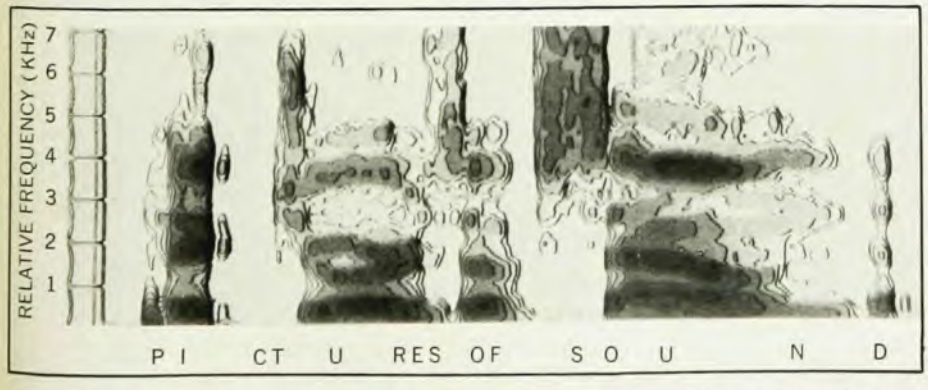
By putting the mathematical developments at the end of the chapters after the descriptive explanations, the authors have attempted to tell a wide audience that "understanding modern astrophysics is fun." Much of the discussion is still complex, however, or presupposes knowledge given later, such as the suggestion in chapter 1 that black holes may provide enough mass to reverse the present expansion of the universe, a concept not discussed until chapter 9. Thus the book is recommended as fun reading for scientists and might be a useful text in a one-semester course for people who have had at least a good high-school physics course or its equivalent.

JOHN R. DICKEL
University of Illinois
Urbana

Speech Synthesis

J. L. Flanagan, L. R. Rabiner, eds.
511 pp. Dowden, Hutchinson & Ross, Stroudsburg, Pa., 1973. $22.00

Of the various problems that have been the concern of speech scientists over the past few decades, the synthesis of speech has come closest to achieving a degree of success in practical application. Speech synthesis has also provided an effective tool for the study of the speech process, because it can be used to produce well-controlled stimuli for investigation of speech perception and it involves modelling of the speech production mechanisms. It is appropriate, therefore, that a collection of papers in the area of speech synthesis constitutes one of the series of books entitled "Benchmark Papers on Acoustics." A group of 46 papers, selected carefully by the editors, James L. Flanagan and Lawrence R. Rabiner, represent a wide variety of subjects ranging from those that are of historical interest (but formed significant and exciting contributions at the time they appeared) to more recent topics on digital techniques for synthesis of speech and on com-



The words "pictures of sound" are graphically displayed on a contour spectrogram. This type of representation provides for more accurate amplitude measurements. Photo from Bell Labs.

puter-based systems for voice response. Much of the more recent work was carried out or was influenced by the co-editors, in their research at the Bell Laboratories.

About one-half of the papers are concerned with vocal-tract acoustics and with techniques for simulating this acoustic process, including analog and discrete-time techniques for modelling the sources of excitation and the transfer function of the acoustic tract. The theory and practice of these aspects of speech synthesis are well developed, and the treatment of these topics in the book is rather complete. Less well advanced is the theoretical and experimental basis for the control of these synthesizers from a discrete linguistic representation. The beginnings of such a theory are contained in several papers by linguists, psychologists, engineers and physicists, but with the exception of one or two papers, this volume cannot be considered as a source of material on the relations between the linguistic and acoustic representations of speech. Attempts to model the speech process with synthesizers have, however, led to a clear specification of the problems that need further research—particularly problems concerned with the acoustic representation of sentences.

The book can serve as a good reference source. It contains basic papers on linear predictive coding, on vocal-tract acoustics, on modelling of the vocal cords, and on speech synthesis by rule—papers that are scattered through a variety of journals. A few of the contributions have not previously been published, at least in the accessible literature. It represents, therefore, an excellent compilation of information for those concerned with the technology of speech synthesis, and for those who wish to use speech synthesis as a tool for gaining an understanding of the underlying speech production and perception processes.

KENNETH N. STEVENS
Massachusetts Institute of Technology
Cambridge

The Solar Chromosphere

R. J. Bray, R. E. Loughhead
384 pp. Halsted, New York, 1974. $30.00

Solar physicists have been studying the solar chromosphere for over a century, since it was first photographed at the total eclipse of 1860. In the years since 1962, added impetus has been given to chromospheric studies on two fronts. First, the announcement in 1962 of the discovery of the 300-second oscillations in the photosphere and low chromosphere has stimulated many detailed analyses of the hydrodynamics of the chromosphere. Second, the Orbiting Solar Observatories and Skylab have opened to observation the short-wavelength emissions of the chromosphere, which are inaccessible from the ground. The recent advances brought about by this impetus have produced a need for an up-to-date, in-depth review of the state of our understanding. *The Solar Chromosphere* by R. J. Bray and R. E. Loughhead has appeared on the scene at a propitious time.

Bray and Loughhead are both principal research scientists in the CSIRO Division of Physics, Sydney, Australia. Their well respected, scientific papers are devoted primarily to the observational study of the fine structure of the solar atmosphere. In addition they have written two other books on solar phenomena that have been published in the same International Astrophysics Series as the present book.

The Solar Chromosphere begins with a historical introduction, which is quite interesting but too brief for my taste. The remainder of the treatise can be logically divided into two parts: The first part consists of those chapters that describe the observational data on chromospheric fine structure, and the second part consists of chapters that describe theoretical studies of the chromosphere.

The observational side of the treatment consists of three chapters covering, respectively, fine structure observed at the limb, structure observed on the quiet disk, and fine structure observed in active regions. Except for the brief mention of fine structure in flares, these three chapters give detailed descriptions of the known types of fine structure. The authors have been very careful to present all the observational evidence, including that which is contrary to their own results, along with a balanced critical discussion. A student first approaching the subject will be overwhelmed by the incredible mass of detail. Therefore, I feel that these chapters will be of most use to advanced students and other solar physicists.

The theoretical side of the book also consists of three chapters, which discuss, respectively, physical conditions in the quite chromosphere, propagation and dissipation of waves, and chromospheric heating. By and large, this second part of the book does not measure up to the quality of the first part. For instance, I believe the authors are wrong to leave the subject of non-LTE to other sources. They recommend that the reader consult R. N. Thomas and R. G. Athay, *Physics of the Solar Chromosphere*, published in 1961, for details on non-LTE theory. However, that work is becoming dated, and, in