to obscure the argument." On points like these, and others, it would have been good to hear from the subject himself.

There is an excellent collection of essays, *Albert Einstein: Philosopher-Scientist* (P. A. Schilpp, Ed.), the value of which is much enhanced by the final article, which is Einstein's reply. It is true that Dirac is a less controversial figure than Einstein; his work has not had the same impact on the world at large, and he is himself legendary for his silences rather than his interventions. Yet he is said to have some interesting views (for example, on the futility of mathematical rigor in physical theory, that the fundamental importance of group theory has been exaggerated, that Bohr's complementarity principle added little to quantum theory, that indeterminism is a defect of contemporary physical theory that one day may be eliminated). Perhaps an invitation to conclude this volume by a review of it would have tempted him out of his habitual reticence. By the way, a theory is given here of this reticence, in one of the several biographical and anecdotal contributions. Mehra tells how Dirac's father, who had been Swiss, ruled that at home French was to be spoken. It seems that Dirac was not very good at French, and so became early a man of few words.

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Tunneling

Superconductive Tunnelling and Applications. L. SOLYMAR. Wiley-Interscience, New York, 1972. xii, 460 pp., illus. $22.95.

The Josephson Effect in Superconductive Tunneling Structures. I. O. KULIK and I. K. YANSON. Translated from the Russian edition (Moscow, 1970) by P. Gluck. Israel Program for Scientific Translations, Jerusalem, 1972 (U.S. distributor, Halsted [Wiley], New York). x, 182 pp., illus. $20.

The introduction of newcomers to the subject of superconductive tunneling will be relatively painless now that these two authoritative books have appeared. Before identifying the appropriate audiences for these books, it is perhaps worthwhile at least to define the words in their titles. "Superconductive tunneling" denotes either the tunneling of condensed pairs of electrons between weakly coupled superconductors (Josephson tunneling) or the tunneling of normal electrons between a superconductor and a normal metal (normal electron tunneling). Josephson tunneling occupies all of Kulik and Yanson's book and half of Solymar's and normal electron tunneling the remainder of Solymar's. In normal electron tunneling the tunneling current depends in detail upon the phononic and electronic properties of the metals used in the tunneling pair; hence such tunneling can be used as a diagnostic probe of various physical properties of a metal. On the other hand, Josephson tunneling is, roughly speaking, independent of the physical parameters of the pair of superconductors and depends only upon the existence of a well-defined superconducting order parameter. The physics of the Josephson effect is elegantly simple and well understood. The utility, present and promised, of the Josephson effect lies in device applications, such as microwave generators, mixers, and detectors and incredibly sensitive voltmeters and magnetometers. Solymar has responded by pitching his book at a mathematical level appropriate for a developmental engineer or applied physicist rather than a many-body theorist.

Solymar's book is richly pedagogical, uniform in depth of mathematical treatment, and extremely well organized. It is self-contained in the sense of supplying the basic and background material required of, for example, a device engineer who knows nothing about superconductivity but plans to work on applications of the Josephson effect. The reader who has a definite commitment to the investigation or use of superconductive tunneling will greatly appreciate Solymar's thorough referencing of the existing literature (964 references). Solymar's high level of scholarship is breached at only one point, where he refers to the quantum interference effect discovered by Jaklevic, Lambe, Mercereau, and Silver as the "Mercereau effect" and, indeed, gives that title to one chapter. This is hardly judicious; nor can it be excused, as Solymar implicitly requests, merely because P. W. Anderson made a similar judgment earlier.

Kulik and Yanson's book, like Solymar's, is authoritative, comprehensive, and well organized. It differs considerably from Solymar's in the level of presentation. For example, chapter 1 contains a full-blown treatment of the many-body theory of the Josephson effect, and thus would be incomprehensible to a large fraction of the readership mainly interested in the second half of the book, which deals, as does Solymar's, with the various observed effects, sample preparation, and device applications.

The device engineer or solid state physicist working with Josephson tunneling cannot afford not to have both these books on his shelf. Solymar's will find additional markets as a reference book for solid state physicists involved with normal electron tunneling and as a textbook for specialized engineering courses on Josephson-effect devices. Both books should be available for reference to students taking graduate-level solid state or superconductivity courses. Solymar's, because of its level, is appropriate as well for final-year undergraduates.

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Effects of the Sun

Solar-Terrestrial Physics. An Account of the Wave and Particle Radiations from the Quiet and the Active Sun, and of the Consequent Terrestrial Phenomena. SYUN-ICHI AKASOFU and SYDNEY CHAPMAN. Oxford University Press, New York, 1972. xxiv, 902 pp., illus., $80. International Series of Monographs on Physics.

Geomagnetism, the two-volume work by Sydney Chapman and Julius Bartels, served as the basic reference and source book on solar-terrestrial relations up to the International Geophysical Year (1958), which initiated the era of artificial satellites and space probes. *Solar-Terrestrial Physics* is intended as its sequel, carrying the subject through 1971 and thus through the first decade of space research. Because of the volume of new material and the breadth of the field, it is an ambitious undertaking for two authors. The authors have made prolific and significant contributions to nearly every aspect of the field, and in my opinion they have succeeded in this latest undertaking. The magnitude of the effort this book represents is illustrated by the time required for preparation. It was begun in 1964, final compilation started in the summer of 1969, and it was completed in February 1971.

The work is effectively a handbook on all topics associated with the relations between the sun and the earth. In addition to the usual or expected topics included under this heading, the

book touches on a number of peripheral subjects such as nuclear reactions in the solar interior and in the earth's atmosphere due to galactic cosmic rays, the internal structure of the earth and global tectonics, electrical charges on interplanetary dust particles, the atmospheric circulation at all levels in the atmosphere, and the interaction of the solar wind with the moon, other planets, and comets.

The book is a compilation and a new organization of published material, from standard references as well as from research articles. Very little new material is presented except for some convenient syntheses in the form of diagrams showing the relations among various phenomena and processes occurring in magnetospheric storms. A valuable feature of the book is the approximately 3500 references grouped according to subject and divided into standard works, contemporary works (monographs), and contributing articles. The book includes a large number of useful illustrations, mostly taken from journal articles.

The format of the book is similar to that of its predecessor, except that its subject range is greater. In the first 450 pages, separate chapters introduce the major physically separable components that enter into solar-terrestrial relations, the sun, the earth, the atmosphere, and the magnetosphere, with an additional chapter on energetic particles, plasma, and electromagnetic waves in the magnetosphere. These chapters emphasize descriptions of the features and properties of each region and the associated physical principles. The remainder of the book details the reactions and interactions of these regions under the stimulation of solar storms and the associated interplanetary and magnetospheric disturbances. We find here a very thorough account of storm-time phenomenology.

I think the section explaining the many indices of geomagnetic activity will be especially useful in clarifying a generally confused subject. Present understanding of storm-time phenomena is incomplete and characterized by competing hypotheses. The book minimizes the pedagogically deleterious aspects of the situation by considering mainly established phenomenology and those theories that are well defined and amenable to mathematical analysis. There is not much emphasis on the many current speculations, which is in keeping with the authors' intention that the book be a permanent reference.

The separation of quiet-time and storm-time phenomena in the book is rigorously maintained. For example, solar activity is discussed only under storm phenomena and not in the earlier chapter on the sun. In all chapters observations, models, and theories are sharply separated, usually by being put in separate sections. The data and their interpretation are not mixed or confused.

The book has been carefully edited. I did not find many misprints. Although each chapter treats a very complete set of topics, most researchers will probably find that the sections devoted to their specialty could profitably be expanded. Of course, that would require expanding an already very large book, and the lack of completeness is mitigated by the thorough bibliography. The policy of avoiding controversies has resulted in the omission of some interesting topics such as the mechanism of field line merging, which is believed to be an essential part of the magnetospheric storm process, and the growth phase and triggering mechanism of magnetospheric substorms.

Sydney Chapman died before the book went to press. He must have known, however, that this final major work would rank with his others as a valuable, authoritative, and permanent reference on the subject of solar-terrestrial relations.

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Atmospheric Processes

Weather Forecasting as a Problem in Physics. ANDREI S. MONIN. Translated from the Russian edition (Moscow, 1969) by Paul Superak. M.I.T. Press, Cambridge, Mass., 1972. x, 200 pp., illus. $12.50.

A. S. Monin of the Institute of Oceanology of the Academy of Sciences of the U.S.S.R. is best known in the West for his contribution to the study of turbulence, but in this work he turns his attention to the larger-scale processes involved in the atmospheric circulation, its variability and degree of predictability. He develops the essentials of the dynamics and thermodynamics involved in a way that, in principle, a physics graduate student could follow, though he might find some of it heavy going. Meteorologists and dynamical oceanographers will find Monin's approach stimulating and sometimes provocative, but this is the measure of a good book.

In the problem of weather prediction, a natural time scale of interest is that for the generation of the kinetic energy associated with the synoptic processes (or the energy dissipation time), which is of the order of one week. Over time intervals short compared to this, it is possible to define adiabatic invariants governing the motion and to consider synoptic regions, say the Western Pacific Ocean and North America, or the North Atlantic Ocean and Europe, for prediction purposes. The first part of this book develops the analytical description of the atmospheric state and motion over these short time scales, pointing out that hydrodynamic theory already can cope with the short-range problem for the pressure, temperature, and wind fields and is making steps toward prediction of cloudiness and precipitation.

The long-range problem, on the other hand, is necessarily global—only the planet as a whole serves as a natural synoptic region. Analytical methods are less useful since the "adiabatic invariants" are no longer invariant over periods in excess of about one week. Monin describes the strides made recently, some associated with the Global Atmospheric Research Program, the numerical models being developed, the problem of uncertainty in initial data, and the consequent limits on predictability. Unanswered questions abound. Why is the intertropical convergence zone not at the equator but usually at latitudes from 3° to 20°? What is the interaction time between the Northern and Southern hemispheres? What is the reason for the 26-month oscillation in the equatorial stratospheric zonal flow? The advent of satellite observations has opened our eyes to a whole range of phenomena previously unsuspected—the spiral structure of cloud systems in large-scale cyclones, the long, narrow cloud streets, and the cell structure of cumulus clouds. In some other respects, satellites have been measurement platforms in search of a problem, but substantially greater information can be expected to supplement surface observations as the needs are recognized and instrumentation developed.

Too few books can be recommended with enthusiasm. This one can.

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