BOOK REVIEWS

Physics of the Earth's Upper Atmosphere. C. O. Hines, et al., eds. 434 pp. Prentice-Hall, Englewood Cliffs, N.J., 1965. $17.35. *Reviewed by Jules Aarons, Air Force Cambridge Research Laboratories.*

The field of upper-atmosphere physics is at a stage where it needs coherence, perhaps even at the expense of not logically explaining all of the data now spewing forth. In the periodical literature we find the fine points examined more finely. We find the reworking of the concept of "dumping" of energetic particles from the radiation belt into the "splash" hypothesis. But the very existence of the belt, the flux, diurnal variation, and precipitation of particles at various energy levels, ought to be turned into a unified picture for the new research worker and student. Even if the data from one particle detector from one space probe at one time do not fit easily into the tale, the story should be told.

From this point of view, *Physics of the Earth's Upper Atmosphere*, edited and written by a group of scientists who are working or have worked at the Canadian Defense Research Telecommunications Establishment, is welcome. It handles the subject ably, emphasizing the program of the group (aurora, topside sounder, and wave motions) but considering the entire field in a comprehensive fashion. It is better rounded than other available texts in presenting amply all aspects of the physics of the atmosphere. The other (fine) work in the field, Ratcliffe's *Physics of the Upper Atmosphere*, is its only competition. The latter is older and contains a series of brilliant reviews but lacks the coherence of the Hines, Paghis, Hartz, and Fejer volume. On the bookshelf now we have the general volume of Ratcliffe, Davies' *Ionospheric Radio Propagation*, and a series of specialized volumes. Six years ago we had only Mitra's *The Upper Atmosphere* (even then aging).

The book's strength is its clarity and unity. It refers to equations and concepts developed earlier in the text; this is common in texts but uncommon in works on ionospheric physics. The book must be used by the lecturer with frequent glances at updating in the periodical literature; for example, the section on the temperature of electrons and ions at high altitudes must be revised with the observations and analysis from incoherent scatter radars. The use of topside-sounder data (of interest to the authors) on occasion goes beyond the available periodical literature but the absence of material on total-electron-content studies by dispersive Doppler and Faraday rotation from satellite transmissions and lunar radar (of interest to the reviewer) is an omission.

This work supplies a serious need in the field and does it well. Once fortified by the coherence of *Physics of the Earth's Upper Atmosphere*, the graduate student and the beginning research worker can face the incoherent world of the periodicals.

Variational Methods in Mathematical Physics. By S. G. Mikhlin. Transl. from the Russian by T. Boddington. 583 pp. (Pergamon, Oxford) Macmillan, New York, 1964. $14.50. *Reviewed by J. Gillis, The Weizmann Institute of Science, Rehovoth, Israel.*

While textbooks proliferate as never before, there are still a few corners of mathematics which lack adequate coverage. The subject of variational methods is one of these, and this translation of an excellent book is therefore timely.

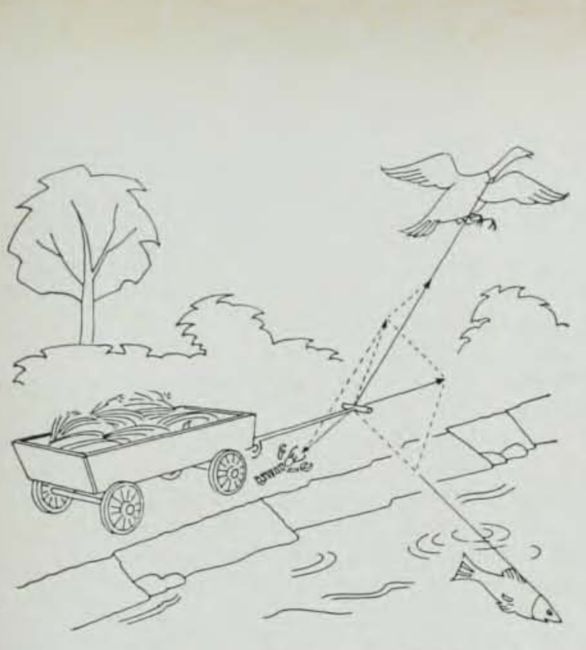
The treatment is careful and thorough, and the classical variational methods are explained and justified in detail. There are a number of worked examples, almost all from problems on elasticity. It is just possible that the book would have made easier reading if many more worked illustrations had been provided.

The discussion is strictly limited to linear problems and no reference is made to recent work (chiefly in the USSR and the USA) on the application of variational methods to nonlinear systems.

There is an interesting final chapter on finite-difference methods. This has only a tenuous connection with the theme and title of the book but is no less useful for that. Its central idea is the "method of straight lines", which has been extensively developed in the Soviet Union. Regrettably little has been published on the subject in English and further exposition of the method would be welcome.

Matter, Earth, and Sky. (2nd ed.) By George Gamow. 624 pp. Prentice-Hall, Englewood Cliffs, N. J., 1965. $11.65. *Reviewed by Michael Danos, National Bureau of Standards.*

Humboldt is supposed to have been the last person who had mastered the complete accumulated knowledge of the Occident. Perhaps this legend is true. The possibility of another such occurrence seems to have been totally eliminated by the almost frightening pace of the development of science and technology in the intervening three-fourths of a century. This growth occurred both in breadth—the number of different specialized fields has multiplied, and in depth—no physicist can hope to know all of physics, and even no atomic physicist can hope to know all of atomic physics. Actually, it has never been possible to know all of a subject; undoubtedly, there existed details in the geography of, say, Switzerland, that were unknown to Humboldt. As for the proliferation of divergent specialized fields, a unification has already set in, and so, in a general sense, Humboldt's feat has again become possible: phenomenology in the different sciences has progressed so far that they have begun to merge by establishing connections with basic principles, say with quantum mechanics, or at least they are close to that stage. The different fields thus fit into a common framework and have acquired a common way of thinking, enabling the crossing of what had been boundaries between



Force resolution à la Gamow. Three biological orders at work and the resultant is go. From the book: Matter, Earth, and Sky.

the fields with a minimum of relearning. Gamow has succeeded in capturing this unity of the physical sciences, and he also has succeeded in demonstrating that science is intrinsically an easy subject.

The principal difficulty in teaching is the contrast between the one dimensionality of speech or writing and the many dimensionality of the interconnections of nature. Fortunately, it is not necessary to teach ab initio; one has available the experiences accumulated by the pupil since his birth. Still, it is always necessary to leave gaps and inaccuracies in the presentation to be, perhaps, filled in later. The ability to optimize the balance between gaps and fluency is one of the main requirements for a teacher. This balance is close to optimal in Gamow's book and the one-dimensional presentation evolves into a full body of understanding by establishing cross links at the appropriate places—in analogy to a complicated protein molecule.

Of at least equal importance is Gamow's "artistic" success in conveying to the reader the beauty and simplicity of the laws of nature. Throughout he limits himself to describing the qualitative aspects of the diverse effects. Gamow has no need to hide ignorance behind formulas. So a facility in the most primitive mathematics is all that is required to follow the presentation. In fact I know of no phenomenon that deep down is more complicated than a statement of proportionality. The complications arise in the integration process; the principles are simple, the consequences of infinite variety. Investigation of consequences on a quantitative plane is the essence of the natural sciences. But understanding of the dependences and interrelations of the different quantities has to be achieved first. This can be done by reading Gamow's book.

The arrangement of the material is conventional. It is divided into three parts of about 200 pages each, beginning with things of everyday size, that is, essentially classical physics, continuing with the microcosm, including chemistry and genetics up to DNA, and concluding with the macrocosm, namely astrophysics and cosmology. The narrative flows easily from subject to subject. It is, however, not deceptively simple; the reader will know that the matter requires his full attention. The style is always fluid, and now and then the presentation is interrupted by interpolations in Gamovian light humor. So, in discussing hydrostatics, he gives as an "example, the hydraulic jack, which permits a lady driver to lift her heavy Cadillac in order to change a flat tire (which she can't do, anyway). . . ." The illustrations are informative and frequently in the same light vein.

Unfortunately I have to make some adverse criticisms. Nothing, not even Gamow's book, is perfect. The number of imperfections is small but, alas, finite. First, some statements are faulty; some are inaccurate. The more fundamental a quantity, the more immaculate has to be the exposition. This basic lemma of textbook writing has been unnecessarily violated by Gamow. The most glaring of these faults occurs in the discussion of kinetic energy. To demonstrate the relation $T = mv^2/2$ he uses a gedankenexperiment in which a weightless cart on which one or two grocer's weights can be placed, can roll horizontally on top of a table. A string tied to the cart leads over a pulley wheel, and its end is attached to a load resting on the floor. The action consists in putting the weights on the cart and giving it a certain velocity. Supposedly the load will be lifted off the floor and rise to a certain height as the kinetic energy of the weights on the cart is converted into potential energy of the load, and it is supposed to rise to double the height if two weights are on the cart and to the fourfold height if the initial cart velocity is doubled.

Instead, something else will happen. As the string becomes taut (poingg) most likely the weights will topple off the cart. If they are well secured, then the string, being light ($\approx$ weightless), will break. If the string has been chosen strong enough, then, after the poingg, momentum will have been conserved and *not* energy. The first experiment will thus give an easily calculable discrepancy from the "expected" ratio of two, and the achieved height will also be off the "expected" value, the remainder of the energy having heated up the string as it became taut. This "simple" gedankenexperiment thus has to be replaced by something else. Admittedly, it is more difficult to convert kinetic energy into potential energy than vice versa, but it can be done.

Second, the book ends on a pessimistic note. Gamow states: All essential problems have been solved.

But many details still have to be filled in. So there is work to be done; keep to the grindstone. What happened to vision and enthusiasm? Is the present situation not almost a repetition of that of the turn of the century? Have not just recently some "sacred" invariance principles, namely, parity and time reversal, been proven not to be obeyed by nature in analogy to the violation of Galileo invariance of yore, and have not the incomprehensible energy sources, the quasistellar objects, made their appearance, the counterpart to the then incomprehensible energy generation in Becquerel's radiation? Are we not right at this moment witnessing the first manifestations of an as yet unknown invariance principle, the analogy of the Lorentz invariance, which will explain the breaking of the symmetries?

These faults of the book are real enough. They are, however, outweighed by a factor of about 500 by the positive aspects. Claims to the contrary notwithstanding, this is not a college textbook for science majors. It is an informative book to be read and enjoyed and perhaps struggled with. As a matter of fact, beginning with a level corresponding to high school, I know of nobody who would not profit from reading Gamow's book. A physicist could improve his teaching skills, a member of the other professions, including that of physicist's wife, could overcome Snow's famous gap between the diverse cultures, and, finally, Gamow himself could eliminate the few remaining faults of the book in anticipation of the next edition. The book is fully worth its price and, in fact, can make an ideal gift, even for physics graduate students.

Introduction à l'Emploi de Rayonnements en Chimie physique. Vol. 1, Cheminement des Particules chargées. By Yvette Cauchois and Yvonne Heno. 271 pp. Gauthier-Villars, Paris, 1964. Paper 52 F.
Reviewed by L. Marton, National Bureau of Standards.

This interesting monograph on the scattering of charged particles forms the first volume of an introduction to the use of radiations in physical chemistry. A brief enumeration of the chapters may give a good idea of the contents. In the first, introductory, chapter are some remarks on the sources of charged particles. A short review is given of the interaction of charged particles with matter, including Cerenkov effect and the effects of annihilation. The second chapter is a good presentation of the different types of collisions, such as elastic, inelastic, and nuclear. The third is devoted to a treatment of bremsstrahlung and is followed by a fourth chapter on total energy losses, straggling, and mean free path. The last third of the book is taken up by appendices, and I would like to single out the excellent treatment of synchrotron radiation although it is extraneous to the main object of the book. In over thirty pages the existing theoretical and experimental material on this type of radiation is reviewed, and it is, as far as I know, the best review of its kind.

I have not previously seen any French book treating electron interaction with matter, and I think it is a definite gain for the French scientific literature to have this book appear. Cauchois and Heno have done a good job in assembling the material and presenting it in a concise manner. Maybe the manner is too concise, and a serious reader will have to go quite extensively to the original literature for more information. Parts of the book reflect the incompleteness of French scientific libraries, by referring to review articles rather than to the original papers.

As usual, there are some items that I would like to submit as possible corrections if there is a second edition. One reason for my complaint is the very long list of errata, which is added as a loose leaf to the volume, containing over forty items, that is, about one correction for every sixth page. I am also inclined to disagree with certain statements, such as, for instance, the remarks about the electron microscope and the x-ray microscope contained in the foreword: "The electron microscope and, in principle, the x-ray and proton microscopes provide a direct view of the morphology of molecules and of other atomic groupings." I think this statement is too optimistic. An added defect of this interesting book is that there is no index. All these are relatively minor defects, and they can be easily improved in a second edition.

The book is written in good style and offers easy reading. For the use of students it would have been preferable to present it between hard covers, rather than as a paperback.

Magnetism. George T. Rado and Harry Suhl, eds. Academic, New York, 1963 and 1965. Vol. 1, 688 pp., $19.00; Vol. 2 part A, 443 pp., $15.00; Vol. 3, 623 pp., $18.00.
Reviewed by R. P. Hudson, National Bureau of Standards.

In times of million-dollar research programs and papers jointly authored by as many names as filled the attendance roster at an olden-days conference, it is perhaps not surprising that a detailed review of the present understanding of magnetism should be undertaken only by enlisting the expository talents of some 50 experts. In a phrase, collective phenomena collectively treated. . . .

Understandably, then, the work takes on the aspect of an encyclopedia rather than the "treatise" claimed by the editors and publishers. Not that the product necessarily suffers thereby as a didactic or reference aid, but it perforce abandons almost all hope of genuinely aesthetic appeal, of furnishing *reading pleasure*, and of easing the reviewer's task!

This "treatise on modern theory and materials" was conceived as a trilogy, but, now that a third volume has appeared after a two-year delay, a fourth volume (in preparation) will be needed to do the subject justice. (This will cover the topic of magnetism and superconductivity, among others.) The style of the individual articles is less varied than one might have expected; the exposition is generally far from leisurely, which is not surprising in view of the encyclopedic coverage and understandable limitations of space.

The range of subject matter can best be conveyed by citing the official list of contents: Volume I—Magnetic Ions in Insulators: Their Interactions, Resonances and Optical Properties. Volume II—Statistical Models, Magnetic Symmetry, Hyperfine Interactions, and Metals. Volume III—Spin Arrangements and Crystal Structure,