taining *A. chroococcum*, was introduced in the U.S.S.R. in the 1930's for improvement of nitrogen nutrition of plants. Although it is concluded that azotobacterin does not provide significantly increased nitrogen from $N_2$ fixation, some ten tables are used to support the conclusion that various aspects of plant growth are improved. In the words of the authors, "Taken together these findings confirm that *Azotobacter* cannot be regarded as analogous to nitrogenous fertilizer. Its favorable effect in certain conditions is connected with the production of biologically active substances. It can now be considered demonstrated that the supplementary use of these compounds favorably influences plant growth."

Findings concerning the effect of blue-green algae on yield of crops, especially rice, are assembled, and techniques for commercial production of algae for field inoculation are discussed. A short paragraph describes the wondrous merits of *Azolla*, an aquatic fern whose early applications to the soil may have yielded a female chauvinist for $N_2$ fixation, "the goddess of *Azolla*." It is perhaps fortunate that the authors' work preceded the abundance of oscillating results reported from attempts to determine the localization of nitrogenase either in the heterocyst or in the vegetative cells or in both.

Many other groups of $N_2$-fixing organisms, some of which are not yet well established as such, and most of which have been less intensively studied, are described, with information on representatives from *Azotomonas, Pseudomonas, Spirillum, Vibrio, Desulfovibrio, Derxia, Klebsiella, Aerobacter, Arthrobacter, Bacterium, Bacillus, Methanobacterium, Chromatium, Rhodopseudomonas, Rhodospirillum, Chlorobium, Chloropseudomonas, Rhodomicrobium, Mycobacterium, Actinomycetes*, and fungi. Subsequent information obtained with improved methodology suggests that $N_2$ fixation probably does not occur in several of these genera; in others it has been well documented, with extraction of the enzyme demonstrated in some cases. However, the authors acknowledge the inconclusiveness of their information on these matters.

We would like to have seen inclusion or amplification of certain aspects which have gained in significance since the completion of the book. Techniques receive little discussion. Of course the technique that has had the greatest impact on measurement of nitrogen fixation, the $C_2H_2$-$C_2H_4$ assay, was only first proposed at the time this book was written. Genetics also receives little attention, and advances of potentially great significance have occurred in the last two years. The associative symbioses are discussed only briefly even though their ecological and agricultural significance may be very great.

Readers are forewarned about several annoyances, some if not all of which may have been introduced in translation. These include frequent errors in references to tables and illustrations, an unusual number of typographical errors, and confusing or incomplete table headings or figure legends. A lack of subheadings impedes rapid scanning.

In spite of these limitations the book will be profitable and essential reading for the specialist who wishes to become knowledgeable about the pre-1966 world literature in the field.

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## Part of Plasma Physics

**Theory of the Unmagnetized Plasma.** David C. Montgomery. Gordon and Breach, New York, 1971. xii, 400 pp., illus. $17.50.

**Theory of Fully Ionized Plasmas.** Günter Ecker. Academic Press, New York, 1972. xvi, 344 pp., illus. $19.50.

Both these books are interesting, rather specialized accounts of one portion of plasma physics. Whereas traditional treatments of the subject give a prominent role to the effects of external magnetic fields, both Montgomery and Ecker choose to treat only the plasma in absence of such fields, a case sometimes colloquially, if inaccurately, referred to as an "unmagnetized plasma." Magnetic fields are essential for a large class of plasma phenomena, and the major portion of research in the field has concerned itself with magnetized plasmas. Nonetheless, there is much to be said for beginning a serious study of the subject with the unmagnetized case. (This reviewer, for one, has done so in his lectures for many years.) Since it is just the collective, self-consistent properties that constitute the most characteristic, and the most interesting, aspect of plasma physics, this area of the subject seems a more fitting point of introduction than the guiding center motion of single charged particles in magnetic fields which is a prerequisite to a proper presentation of the magnetized plasma theory. However, to exclude magnetic field effects entirely from a book the size of these does seem to carry a good thing rather too far. (Apparently Montgomery felt some qualms on this point, since he includes, in a brief appendix having little logical connection with the rest of the book, a short summary of the solution of the linearized Vlasov equation for a magnetized plasma.)

Both books suffer from an apparent lack of clear intent on the authors' part as to the level of their audience, the discussion in some places being geared to a reader quite unfamiliar with plasma physics and in other portions treating material that is very advanced or recondite. Aside from this, and the restriction to the unmagnetized plasma, they have not a great deal in common as regards content and still less as regards style.

Much of Montgomery's book is very crisply written, liberally seasoned with candid, sometimes trenchant, expressions of the author's prejudices. The first five chapters give a good account of what might be called the "classical" portions of the theory of unmagnetized plasmas. As is perhaps befitting such material, the presentation is somewhat dry and bloodless, emphasizing mathematical formalism more than physical pictures, but I would recommend it as a good introduction to the subject for, say, a young elementary particle theorist who wishes to learn plasma physics. The next two chapters, on nonlinear Vlasov phenomena, are perhaps too detailed and too near the frontier of research to be of maximum value for the beginner, but they should be valuable as a well-annotated guide to the literature of the subject for professional plasma physicists.

Chapters 8 through 11 present a very detailed discussion of kinetic theory. This is inherently difficult material, conceptually, mathematically, and even notationally, where clarity and simplification are an urgent necessity. Unhappily, the author has chosen to present not only the Klimontovich-Dupree formulation of this material, which he correctly recognizes as the one best suited for exposition, but also the more traditional Bogolyubov-Born-Green-Klimontovich-Yvon hierarchy, presumably because, in his words, "Only when one has calculated the fluctuation spectra both ways is he likely to realize the extent to which the Klimontovich-Dupree approach is simpler." The reader who has fought his way through two formalisms to achieve this realization may well wish the author had encouraged him to accept this on faith, with appropriate references to the literature to convince the skeptics. In general, a sparser exposition of this portion of the material not only would have enhanced its clarity, but also would have left more room for the numerous topics of interest in unmagnetized plasmas which are omitted or treated so briefly that reference to the original literature is indispensable. The book concludes with a chapter on "Some illustrative experiments," an unusual feature in a book of this character, but certainly a most valuable one. It partially compensates for the somewhat abstract character of the theoretical discussions in the main part of the book.

Ecker's book suffers most from a turgid, heavy-handed expository style, with formal and mathematical considerations completely dominating physical insights or motivations. It is unsuitable for an introductory course, even at the graduate level; in fact, it is not clear to what class of readers it will be really useful. There is heavy emphasis on statistical mechanical considerations, the first chapter being devoted to a detailed and lengthy (72 pages) exposition of equilibrium theory for a Coulomb system, using cluster expansions. Again, this is a relatively complicated subject and the author's exposition is neither clear nor felicitous. (It is also so far from the current areas of research interest in plasma physics that it is hard to understand why it was included.) At all the difficult points, the reader is referred to the original literature. This is followed by an equally confusing chapter on the nonequilibrium theory, and then by a presentation of the "classical" Vlasov equation theory which is much less satisfactory than that given by Montgomery. Chapter 4 contains a discussion, along quite standard lines, of "collisional" effects, that is, the consequences of including correlations of the fluctuations about the ensemble average.

In the treatment of all of this material, the author restricts himself to electrostatic fields, presumably for simplicity and clarity of exposition. Unfortunately, he achieves neither. The last two chapters consider the general electromagnetic field, a subject that has been somewhat less worked over, in texts and original literature, than the subject matter of the first part. Single particle radiation, the dispersion relation for electromagnetic waves, collisional effects, light scattering, and similar topics are discussed. While the exposition seems better than in earlier chapters, there is little here that has not been presented as well, or better, in other texts or even in the literature.

Since only about a third of the material covered by Ecker is treated also by Montgomery, one is tempted to characterize the two books as being somewhat complementary. Unfortunately, little of Ecker's treatment is characterized by the freshness of approach or clarity of exposition that Montgomery achieves in many portions of his book. Whereas the Montgomery book could very nicely serve as a basis for an advanced, one-quarter or one-semester seminar on plasma physics, the one by Ecker seems suitable neither for this use nor as a text in a plasma physics course.

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## A Problem in Statistics

**Robust Estimates of Location.** Survey and Advances. D. F. ANDREWS, P. J. BICKEL, F. R. HAMPEL, P. J. HUBER, W. H. ROGERS, and J. W. TUKEY. Princeton University Press, Princeton, N.J., 1972. x, 374 pp., illus. Cloth, $12.50; paper, $6.

The problem of robust estimation is to find an estimator for an unknown quantity under various conditions underlying the observations. There are various aspects of conditions that may have to be considered, but attention has been focused mainly on the shapes of probability distributions—more specifically, on the possibility or even the near certainty of some departure from normality. In reality, the exact shapes of the probability distributions cannot be known; only some vague range of possible shapes is assumed, and the estimator must be "robust" in the sense that it has uniformly relatively high efficiency over a class of distributions even though it may be slightly less efficient than the "optimum" estimator for a specific distribution.

This problem itself is not necessarily new, and can be traced back to Gauss himself, who first established the optimality of the standard technique of estimation under the normality. But a revival of interest in it has recently been initiated by J. W. Tukey, who distinguished the concept of "efficiency robustness" from that of "validity robustness" and emphasized the former in the problem of estimation.

So far research has been concentrated on the simplest case, that is, on the estimation of a location parameter where only one unknown quantity $\theta$ is involved and the observations $x_i$ are equal to the sum of $\theta$ and the independent error $V_i$, which is usually assumed to be continuously and symmetrically distributed around zero.

There have been proposed four kinds of estimators. One is the linear combination of order statistics, the estimator of the form

$$\hat{\theta} = c_1x_{(1)} + c_2x_{(2)} + \ldots + c_nx_{(n)}$$

where $x_{(1)} < x_{(2)} < \ldots < x_{(n)}$ are ordered values of $x_i$. Especially, the trimmed means which correspond to the case when $c_1 = \ldots = c_r = c_n = \ldots = c_{n-r+1} = 0$, and $c_{r+1} \ldots c_{n-r} = 1/(n-2r)$ have been investigated. The second is the class of so-called M-estimators proposed by Huber which is equal to the value of $\theta$ minimizing

$$\sum_i \psi\{(x_i - \theta)/s\}$$

where $\psi$ is a convex function and $s$ is some estimator of the scale. Huber especially recommended the type where $\psi$ is defined to be

$$\psi(x) = \begin{matrix} x^2 \text{ for } |x| \leq k \\ kx \text{ for } |x| > k. \end{matrix}$$

The third is the estimators derived from the rank tests, among which the only practically tractable one is Hodges-Lehmann's, which is derived from the Wilcoxon signed rank sum test and is defined by

$$\hat{\theta} = \text{median of } (x_i + x_j)/2 \text{ for all } i < j.$$

The last group are the estimators which are "adaptive" in the sense that the estimation procedures include some steps of estimating the shape from the sample and choosing the estimator based on it. Such a possibility was first suggested by Stein, but practical procedures were proposed by Hogg, Takeuchi, and Johns.

Recent studies by various authors