Book Reviews

Fundamentals of Plasma Physics. By V. E. Golant, A. P. Zhilinsky, and I. E. Sakharov. John Wiley and Sons, Inc., New York (1980). 405 pp. $55.95.

Few phenomena in plasma physics are more deserving of the adjective "fundamental" than Landau damping, and few equations are more fundamental than the Vlasov equation. Strangely enough, neither of these significant Russian contributions appears in the volume by the three Soviet authors. Lest they be accused of anti-Soviet bias, I should hasten to add that one would look in vain in this book for Alfven waves, ion waves, beam plasma instabilities, and a host of other fundamentals of plasma physics. Selected topics in plasma physics would probably be a more appropriate title.

Having thus criticized their selection of topics, I should point out that the phenomena that are covered in this volume are thoroughly and intelligently treated, and the mathematical treatment is often complemented by physical insights.

About two-thirds of the book treats collisional plasmas in the presence of neutrals. Elastic as well as inelastic collisions, including ionizing collisions, are discussed in detail, and a brief description is given of the interaction of charged particles with solid surfaces. Then the kinetic equation and its consequences of interest to gas discharge type plasmas, like distribution functions in electric fields and ionization equilibria, are given. Chapter 6 treats the moment equations, and Chap. 7 transport processes in the absence of magnetic fields.

The discussion of topics of interest to the fusion-oriented plasma physicist commences in Chap. 8 with the description of single particle motion in magnetic fields. This chapter also deals with some basic phenomena of collisionless plasmas like plasma diamagnetism, polarization, and motion across magnetic field lines. It also contains a good description of banana orbits in tokamaks and single particle motion in a mirror geometry. Chapter 9 deals with transport processes in both weakly and strongly ionized plasmas in magnetic fields. This chapter even contains a dispersion relation (there should have been many more) for a collisional drift wave.

The last chapter treats magnetohydrodynamic equilibria and a few instabilities, like the flute and interchange modes. The stabilized z pinch with a thin surface current is also adequately discussed.

It may be the different interest of the three authors that is responsible for the somewhat schizophrenic nature of this book. Is it addressed to the gas discharge physicist or the student of magnetic confinement fusion? While I cannot speak for the former, the latter is certainly shortchanged.

The book was used as a textbook at the Leningrad Kalinin Polytechnic Institute. It contains no problems for the students.

The translation is adequate except for occasional lapses like "motion equation" instead of equation of motion, or "Sydem criterion" instead of Suydam criterion.

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July 29, 1981

About the Reviewer: George Schmidt is professor of physics at Stevens Institute of Technology and is the author of Physics of High Temperature Plasmas *published by Academic Press, first edition 1965, updated second edition 1979. His research interests are plasma physics and, currently, stochasticity theory and its application to plasmas.*

Structure Shielding Against Fallout Gamma Rays from Nuclear Detonations. L. V. Spencer, A. B. Chilton, and C. M. Eisenhauer. NBS Special Publication 570, U.S. National Bureau of Standards (Sep. 1980). For sale by Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 967 pp. $20.

It is only occasionally that an exhaustive treatise on a shielding subject is published. We have one now in the nearly 1000-page book *Structure Shielding Against Fallout Gamma Rays from Nuclear Detonations* by L. V. Spencer, A. B. Chilton, and C. M. Eisenhauer.

All of the authors have been leading researchers in shielding, especially fallout shielding, for many years. Spencer and Eisenhauer are especially well known for their development and application of the moments method for gamma-ray penetration and, with N. FitzSimons, of the so-called "Standard Method" for fallout shielding analysis developed in the 1960s. Chilton is especially well known for his research on gamma-ray reflection and other problems related to shelter shielding design. Although very few people are engaged these days in fallout shielding analysis, the motivation for it has not entirely disappeared, considering the nuclear arsenals in various parts of the world. There is the possibility, too, of some spinoff–the technology can also be used for analysis of reactor accident fallout.

Most shielding calculations nowadays generally employ one or more of the popular methods–discrete ordinates, Monte Carlo, or point-kernel integration–but this book describes an altogether different approach. Like the point kernel-kernel method, the engineering standard method starts with infinite-medium moments-method data, but unlike the point-kernel method, it makes extensive use of angular distributions to account for geometric structure. Reliance is also placed on experimental results and some Monte Carlo calculations to validate the overall technology, and these aspects are fully discussed. It is, indeed, an engineering method, as one would conclude from seeing thicknesses in units of pounds per square foot and absorption coefficients in units of square feet per pound!

A short description of the standard method is in order here. It is an extension of a method originally presented by Spencer in NBS Monograph 42 in 1962. Later, fundamentals of the present method were given by Eisenhauer in NBS Monograph 76 (1964), and the method was more fully elaborated in OCD document TR-20 and its revisions (1967 to 1974), a text written in a style suitable for teaching. To obtain a clear picture of how this technology developed, one can refer to an interesting chart in the present book, which shows the various milestones, published documents, and computer programs that implement the method. The latter were especially useful in the National Fallout Shelter Survey, which examined and evaluated ~350 000 buildings distributed throughout the U.S. The survey is also discussed.

The original method may be summarized by stating that the dose D measured in a structure (such as a blockhouse) is represented as the sum of contributions D_i entering through different wall sections and ceiling. Each of the D_i is the product of a barrier factor $B(X_i)$ and a geometry factor $G(X_i \omega_{ij})$. Each geometry factor consists of one or more terms corresponding to "partial surfaces" chosen to represent approximately the actual source surface whether primary or secondary. If the reference detector response for the barrier factors is taken to be a standard value D_0 3 ft above an infinite, smooth, air-air interface having uniform contamination equal to that on and around the structure, the complete expression for the detector response takes the form

$$D = D_0 \Sigma B(X_i) [\Sigma G(X_i, \omega_{ij})] \ .$$

Structure configurations exist that call for more complicated expressions than this. For example, in maze-type geometries the radiation may have to turn corners to reach the detector. In basements below grade the detector response may consist largely of contributions due to gamma rays that have scattered downward from the exposed superstructure through intervening floor slabs. Such higher order contributions give terms involving additional factors, but otherwise are of the same type as the terms in the above equation.

Many variations of the functions B and G are developed, and each variation (frequently depending on angular-dependent aperture parameters) is represented by its own symbol. There are so many functions that a novice will find them bewildering. It would have helped to have a "function glossary."

All tables and graphs of the barrier and geometry functions were obtained from four types of basic data:

1. plane isotropic source case
2. point isotropic source case
3. plane oblique source case
4. albedo results.

The first three were obtained using moments methods; the last required Monte Carlo calculations. The assumed source energy spectrum was that for 1-h-old fission products. Data for ^{60}Co and ^{137}Cs are given in an appendix for shields of concrete and water.

In the Preface the authors give the background and purpose:

> Attempts to develop satisfactory methods for estimating the shielding properties of ordinary buildings against gamma rays from radioactive fallout began in the early 1950s. Intensive research of many kinds was carried out during the decade from about 1956 to 1966; but in the past decade, there has been a steady decline of new research on these problems. There are many reasons for this, one of which is *not*, however, the achievement of a fully satisfactory state of the technology. An updating and improvement of the material present here is overdue, but is not easily effected.
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> We intend this publication to serve 1) as a reference for engineering students, 2) as a reference and source of ideas for engineers engaged in research and development on radiation shielding problems, 3) as a basic reference for architects and engineers concerned with the design of buildings with protective features, and 4) a reference for officials responsible for civil protection in nuclear emergencies. These multiple uses are expected partly because this is the first attempt to bring together and summarize much of the material presented.

The book summarizes the extensive effort, much of it by the authors, during the 20 years following 1956 to understand the protective capability of structures against fallout gamma radiation from nuclear weapons. It describes both experimental and theoretical efforts that were sponsored for the most part by the U.S. Defense Civil Preparedness Agency, now part of the Federal Emergency Management Agency.

The first two chapters of the book give a historical review of methods and programs associated with fallout radiation shielding, and a description of the physical and biological aspects of fallout radiation. The production, transport, and deposition of fallout are described and biological hazards are reviewed.

The next three chapters describe a series of calculations that formed the data base for a set of procedures to evaluate shielding from fallout radiation. Basic concepts such as cross sections, flux density, and energy deposition are discussed. Examples of photon transport in simple configurations are given. A detailed discussion is given on the moments method of photon transport. Curves are given for calculating photon transport in configurations applicable to structures.

The next six chapters describe the procedures for calculating protection from fallout radiation and the extensive series of experiments that was carried out to test these procedures. Discussion begins with the simple configuration of a point detector located above a plane isotropic source and proceeds to increasingly complex structural configurations. Comparisons of experimental and calculated results are given for many of these configurations.

The final chapter discusses sources of error and sensitivity studies. The problem of accuracy, in general, and sensitivity of protection factors to uncertainties in the calculations are discussed.

This massive work is far more than a state-of-the-art report; it is a textbook on gamma-ray transport, the moments method of solving the Boltzmann transport equation, fallout gamma-ray sources, fallout phenomena, shielding concepts, penetration data, field experiments, and shielding analysis (especially the Standard Method). This book was obviously prepared with great care. I noticed only one misspelled name, and there were very few typographical errors. The authors also were very careful to distinguish between flux density and current, thus avoiding a problem that is frequently encountered in such discussions. Each section has a long list of references, mostly from the 1950 to 1978 period. There is an author index and a subject index, both of which seem to be quite thorough.

This book is a must for any engineer interested in fallout shielding and would be a valuable reference to anyone interested in gamma-ray shielding applications.

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July 31, 1981

About the Reviewer: David Trubey has been engaged in radiation shielding studies at the Oak Ridge National Laboratory since 1953, and is presently a research staff member of the Radiation Shielding Information Center. He is chairman of the American Nuclear Society (ANS) Standards Subcommittee ANS-6 concerned with radiation protection and shielding, and is leading a work group compiling and evaluating gamma-ray attenuation data. Mr. Trubey, who has contributed to many publications on shielding, received his academic training at Lawrence Institute of Technology, Michigan State, and the University of Tennessee.