Impurities can also prevent effective neutral-beam heating of a plasma by altering the beam energy-deposition profile. Many atomic processes must be understood to calculate the effects of impurities on plasma energy balance. Impurity production by wall processes is discussed in one paper. Another topic discussed in the first series of papers is methods of impurity control, which will be a difficult issue for the design of the next generation of fusion reactors. One possibility discussed for impurity control is the use of a divertor, in which plasma near the outer edge of a tokamak is diverted to a remote area.

The next five papers are devoted to theoretical methods for atomic collisions. These papers on the whole are disappointing, because they are addressed to specialists in atomic theory, which reduces their accessibility to nonspecialist readers. Shortcomings include a relative paucity of simple physical explanations, incomplete discussion of the region of validity of each theory, and insufficient comparisons of results of various theories and of theory with experiment. An exception is the article on theoretical studies of electron-impact excitation of positive ions. Electron-impact excitation of impurity ions is a dominant mechanism for producing radiation which is emitted from hot plasmas. In addition, the relative intensity of impurity lines excited by electron impact provides a sensitive diagnostic of temperature and density within the plasma. The papers on theoretical methods for ionization and on the theory of recombination processes, both very important topics, are unfortunately too formal and detailed to be within the scope of interest of most readers.

Experimental atomic physics is discussed in two excellent papers, one by K. T. Dolder on ionization and excitation of atoms by electrons and on ion-ion collisions, the second by F. J. de Heer, who writes about experiments on electron capture and ionization in ion-atom collisions. Dolder compares various experiments, and discusses comparison of experimental and theoretical results. de Heer has written an excellent review of ion-atom collisions, with some emphasis on collisions of multiply charged ions with atomic hydrogen. Experimental methods are discussed, as are ion sources for multicharged ions. Experimental results are compared with theory. Both papers have balanced coverage, are clearly written, and the references are comprehensive.

Highly ionized atoms are discussed in the next three papers. The paper by I. Martinson on experimental studies of energy levels and oscillator strengths of highly ionized atoms nicely complements the paper on theoretical studies of oscillator strengths for the spectroscopy of hot plasmas, by M. Klapisch. Both papers are clear, readable, and comprehensive. Energy levels, structure, and lifetime data for highly ionized atoms are all necessary for fusion applications, both for plasma modeling and for spectroscopy and diagnostics of hot plasmas. A third paper in this group discusses spectroscopy of highly ionized atoms in the interior of a tokamak plasma, with iron ions in the Princeton Large Torus as an example.

A final paper in the volume discusses thermalization and exhaust of helium in a future thermonuclear reactor. Neutrons from the D-T reaction go directly to the walls of the reactor, where their energy is transformed into heat, and have no direct influence on the power balance of the plasma. The alpha particles from the D-T reaction, however, must be confined and thermalized to obtain plasma ignition.

This book is a sensible collection of well-written papers on atomic and molecular processes in controlled thermonuclear fusion. Its major strengths are the clear discussions of tokamak reactors, of experimental atomic-collision processes relevant to fusion, and of spectroscopy of highly ionized atoms. One annoying detail is that a few of the bibliographies reference only the first author, the co-authors being relegated to et al., a practice that must be discouraging to the co-authors. The book has an index, which is of help to the reader, especially since, of necessity, the various chapters overlap. The choice of topics is very good, especially the emphasis on impurities. However, a discussion of mirror reactors would have increased the breadth of the book, as would a comprehensive discussion of negative ions.

This book should be of interest and use to nuclear engineers and atomic and plasma physicists interested in or working on controlled thermonuclear fusion. It provides a good understanding of the atomic and molecular processes relevant to magnetic-confinement fusion reactors. The bibliographies are current up to 1979; the interested reader should quickly be able to update the bibliographies by reference to the current literature, which is necessary because the field of atomic processes relevant to fusion is rapidly evolving.

Alfred S. Schlachter

Strahlenzentrum der Justus-Liebig Universität
Institut für Kernphysik, Leihgesterner Weg 217
6300 Giessen, West Germany

July 7, 1981

About the Reviewer: Alfred S. Schlachter has been a staff physicist in the Accelerator and Fusion Research Division of the University of California Lawrence Berkeley Laboratory since 1975, and is presently on leave at the Radiation Center of the Justus-Liebig-Universität in Giessen. Since completing his graduate studies at the University of Wisconsin, Madison, he has held appointments at Saclay, at the University of Paris (Orsay), and at Fontenay aux Roses. Dr. Schlachter's current research interests are in basic studies of ion-atom collisions, especially of the ionization of atoms in collision with highly charged ions.

Nuclear Chemistry Theory and Applications. G. R. Choppin and J. Rydberg. Pergamon Press, Oxford (1980). 667 pp. $29.50 flex cover; $87.00 hardcover.

The most widely used textbooks of nuclear chemistry in the U.S. give strong coverage of the fundamental physics underlying the subject and more cursory treatments of the associated chemistry and applications. European textbooks place less emphasis on the former and more on the latter. Choppin and Rydberg have attempted to write an up-to-date textbook in the European tradition, with an emphasis on chemistry and nuclear applications. (Fortunately, however, they have deviated from the European tradition by including problems at the ends of chapters, although the problems tend to be rather mundane.) In that attempt, they have been quite successful in a number of areas, especially their extensive coverage of nuclear energy, its promise and problems, the biological effects of radiation, the synthesis of elements in stars, applications of radioactive tracers, and the synthesis of new elements. They deal with nuclear energy and its associated hazards very thoroughly and effectively, including the principles of nuclear reactor operation, the chemistry and physics of the fuel cycle, the release of radioactivity during normal operations, the probability of accidents (drawing extensively on the Rasmussen report), waste disposal problems and the experience derived from the Okla natural reactor, the proliferation problem and proliferation-free fuel cycles, and the probable somatic and genetic effects of radiation exposure from the nuclear industry. Opponents of nuclear energy would no doubt find the treatment of the problems much too optimistic, but the authors have done an excellent job of presenting the data in a straightforward, scientific manner that places the dangers of nuclear energy in context with other radiation exposures (mainly natural and medical) and other types of hazards. Although they don't belabor the point, they include data that suggest possible beneficial effects of small radiation doses (e.g., decreased malignant mortality rates in U.S. states that have higher natural radiation levels). One shortcoming in this regard is that specific sources of information are rarely indicated. It would, for example, be interesting to know the source of a statement that an estimated "28 persons per day die in New York by excessive SO_2 emissions."

The chapter on synthetic elements is quite interesting and provides a good review of the principles and clever experimental methods (e.g., recoil collection methods) that were vital to the discoveries and useful in other areas. Discoveries of the transuranium elements and the completing claims of Berkeley and Flerov's group in the Soviet Union for elements 102 and above are extensively discussed, but a curious omission is the incorrect discovery of nobelium (Z = 102) by scientists at the Nobel Institute with collaborators from Argonne and Harwell.

In view of the emphasis on uses of nuclear chemistry, the treatments of nuclear analytical methods and medical diagnoses with tagged molecules are surprisingly brief relative to their widespread uses. During the middle 1960s, experimental nuclear chemistry underwent a revolution caused by introduction of lithium-drifted germanium [Ge(Li)] gamma-ray detectors, which have much better resolution than the NaI crystals they replaced. Their initial impact was in fundamental studies, especially nuclear spectroscopy, where they provided energies reliable to 0.1 keV and often revealed dozens of transitions that were not resolvable with NaI. The germanium revolution quickly influenced applications, especially activation analysis, in which the superior resolution allows one to observe gamma rays of up to 40 elements in complex irradiated samples. Even tracer applications are affected, as one can often use many gamma-emitting isotopes simultaneously and resolve them with germanium detectors. Despite the great impact on Ge(Li) detectors on the field, Choppin and Rydberg have treated them very briefly. For example, they use a NaI spectrum to illustrate the features of gamma-ray spectra instead of using Ge(Li), which would show the features more clearly.

The coverage of fundamental nuclear concepts is disappointing—far from up to date and without great depth. The chapter on nuclear structure, for example, handles the shell model rather well, the rotational model of deformed nuclei briefly, and the vibrations and coupling of quasi-particles in spherical nuclei not at all. Although beta decay and fission have been more the "property" of nuclear chemists than physicists, neither subject is dealt with in great detail. While the basic portions of the text may be adequate for students who wish merely to apply existing nuclear methods to their particular problems, they would not provide the grounding needed to allow the students to advance the state of the art.

The book is written at a level that should be understandable by the intended users. Its organization is generally good, except that detection methods are not discussed until Chap. 17, which follows radiation effects on biological systems. The book is very large and could have been improved by judicious editing of side issues. Although obvious errors are rare, there are occasional oversimplifications, e.g., that the $1/v$ law for neutron cross sections arises just from the wavelength of the neutron without reference to resonances. The 14 appendixes contain a large store of information of value to students, including a chart of the nuclides.

In summary, although Choppin and Rydberg's treatment of fundamentals is weak, their book should serve quite well as a text for courses designed strictly for users of nuclear methods, being so complete that students will keep and consult it long after the course is over.

Glen E. Gordon

University of Maryland
Department of Chemistry
College Park, Maryland 20742

July 20, 1981

About the Reviewer: Glen Gordon is professor of chemistry at the University of Maryland, where he has been a member of the staff since 1969, following teaching and research responsibilities at the Massachusetts Institute of Technology. He has served as advisor to the Electric Power Research Institute, and the Oak Ridge and Livermore national laboratories. Dr. Gordon's current research interests are in nuclear analytical methods, atmospheric particulate matter, and the use of trace elements in biological systems. His graduate studies were at the University of California, Berkeley.

Two-Phase Flow and Heat Transfer in the Power and Process Industries. By A. E. Bergles, J. G. Collier, J. M. Delhaye, G. F. Hewitt, and F. Mayinger. Hemisphere Publishing Corporation, Washington, D.C. (1981). 707 pp. $55.00.

The dramatic growth of interest and research activities in two-phase flow and heat transfer in recent years is best demonstrated by the sudden appearance of numerous conference sessions, symposia, and workshops, as well as books and proceedings devoted to this subject. Although the subject has a broad application base in various power and process industries, much of the recent impetus has been provided by the thermal-hydraulic aspects of nuclear reactor safety. The rapidly expanding literature on the subject, however, makes it a formidable task to present a mature, cohesive, and comprehensive treatment in a single volume by a single author. The present book represents a gallant effort to fulfill such a need.

The book is an outgrowth of lecture notes prepared earlier for a sequence of short courses on two-phase flow and heat transfer by the five authors, all of whom are well-recognized leaders in the field. It contains a strong international flavor as the authors consist of one American (AEB), two Englishmen (JGC and GFH), one Frenchman (JMD), and one German (FM). As compared to other treatises on the same subject, this book is unique in its relatively broad and up-to-date coverage ranging from fundamental analysis and mechanisms to practical plant design and operational safety. It even includes, as the last chapter (Chap. 24) of the book, an excellent review of the historical developments in two-phase flow and heat transfer since its inception.

The book starts with five chapters on two-phase flow fundamentals including flow patterns, basic equations, frictional pressure drops, singular pressure drops, and annular