> Human inventiveness in the fields of science and technology have outstripped human fertility. . .
>
> Malthus' second nonsense is harder to forgive. There is no evidence in history, not at his time or after, to justify the use of the mathematical expressions he cited.

Teller then gives a table (Fig. 5.1, p. 145) on population that is marred by an evident numerical disagreement. The date of the building of the great pyramid of Khufu (Cheops) is given in the text as 2560 B.C. but in the table as 2650 B.C.

Mankind is concerned about the future of the world and the possibility of the world's end. After discussing other myths, Teller points out that one possibility is the coming of the next ice age. There is some evidence indicating that the next ice age might overwhelm us within a single century. The difference is that the world has science and technologies not present when the last ice ages were experienced. Mankind can look forward to the future with hope if all the human gifts that distinguish us from other living creatures are used. It is within possibility that the menace of oncoming glaciation will provide human beings with sufficient motivation to unite against a common menace of nature. Humanity in all its history has repeatedly escaped disaster by a hair's breadth. Total security has never been available to anyone. To imagine it to exist is to invite disaster.

Teller discusses at some length the problem set by the reality and realization of the world's energy shortage. In the current discussion he notes that one of the postulates is that society should get away from exhaustible energy sources and concentrate on renewable forms. This prospect is often somewhat erroneously perceived and, in fact, even in his discussion it is not made clear that abundance of even something already understood like nuclear fission energy is or may be sufficient without being renewable to relieve fears of shortage when taking account of the availability of thorium as an energy source.

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About the Reviewer: Bennett Lewis, a student of Lord Rutherford, has enjoyed an illustrious career in physics with particular interest, of course, in the nucleus. Following the war years, when he was a civilian scientific officer with the U.K. Air Ministry, he began work in nuclear energy in Canada, first with the National Research Council, then as senior vice-president, Science, of Atomic Energy of Canada Limited, a position from which he is now retired. Dr. Lewis continues his contributions to physics through an association with Queens University at Kingston.

Atomic and Molecular Processes in Controlled Thermonuclear Fusion. Edited by M. R. C. McDowell and A. M. Ferendeci. Plenum Press, New York (1980). 506 pp. $55.00.

This volume contains the texts of the invited lectures to the North Atlantic Treaty Organization Advanced Study Institute on Atomic and Molecular Processes on Controlled Thermonuclear Fusion, which was held in France in August 1979. The first part of the book introduces the physics of controlled thermonuclear fusion, especially in tokamaks, while the remainder of the book is devoted to a survey of relevant atomic and molecular processes.

Fusion presents a hope for the energy future of mankind, for a nearly limitless source of energy, having minimal impact on the ecosystem. A very high temperature is required for nuclei to overcome their mutual repulsion and to fuse together. The most easily attainable fusion process is the deuterium-tritium (D-T) reaction: deuterium and tritium fuse to form a helium nucleus (alpha particle), a neutron, and considerable energy. Ions in a plasma must be heated to a temperature of 50 to 100 million degrees. This high temperature requires that the plasma be isolated from the walls of the containing vessel, and that powerful means be used to heat the plasma. However, once the plasma is hot, if the plasma conditions are correct, the alpha particles created by the fusion reaction will alone provide sufficient energy to keep the plasma hot, a condition called ignition.

Two examples of fusion are stars, held together by gravity, and therefore large, and the hydrogen bomb, too powerful to tame. Two schemes presently under study for fusion reactors are somewhat analogous to the above: magnetic confinement, in which a low-density plasma is confined by a magnetic field; and inertial fusion, in which a small pellet of hydrogen, bombarded by an intense pulse of laser light or particle beams, is both heated and inertially compressed for the few nanoseconds necessary for fusion to occur. The fusion-reactor concept that is presently the most advanced is that of magnetic confinement of a plasma. This book is mainly devoted to tokamaks: plasma-containment devices utilizing closed magnetic field lines in a toroidal geometry. Another approach to magnetic confinement, the magnetic mirror, uses cylindrical geometry. Although mirrors are not discussed in this book, much of the physics is applicable to both magnetic confinement systems.

The nuclear physics of fusion has been known for many years. There are, however, many atomic, plasma, engineering, and technological problems to be solved before a practical fusion reactor is feasible. There is a need for considerable atomic and molecular data for all aspects of controlled thermonuclear fusion: in confinement, heating, energy balance, plasma-wall interactions, diagnostics, and the problems associated with impurities in the plasma. Furthermore, it is necessary for plasma and atomic physicists, for theoreticians and experimentalists, to communicate with each other and to exchange ideas, to reach the goal of a practical and economically viable fusion reactor. It was the aim of this conference and of these lectures to facilitate such communication.

The first five papers in this volume are devoted to a discussion of the basic principles of fusion reactors, especially tokamaks, of the relevant atomic processes, and of the role of plasma impurities in the operation and energy balance of a tokamak. Following an introduction to atomic processes in tokamaks by M. R. C. McDowell is an excellent and comprehensive article by M. F. A. Harrison on the relevance of atomic processes to magnetic confinement and the concept of a tokamak reactor.

Impurities are unavoidable in a tokamak plasma. They arise mainly from imperfect confinement of the plasma and from sputtering of wall material and of the limiters, which keep the plasma from touching the wall of the confinement vessel. Impurity atoms released into the plasma are quickly ionized into high charge states. The presence of these impurities has many effects, mostly deleterious, on the plasma. Radiative losses provide sharp limits to the maximum tolerable level of a given impurity ion to achieve plasma ignition.

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.

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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,