not with the interaction between them. Two reports that were well balanced between theory and experiment concerned charge-exchange of high-charged ions in hydrogen and H_2 presented by H. B. Gilbody and electron ionization of multicharged ions presented by D. H. Crandall. Since charge-exchange involves a three-body collision, accurate theoretical methods have been difficult to formulate. Developments in both semiclassical and in a full quantum treatment have resulted in computed cross sections that compare favorably with experimental data. A similar situation does not exist for electron ionization of highly charged ions. Present theory is only capable of predicting cross sections to within a factor of 2 of those found experimentally. Currently, in modeling of plasma properties such as ionization equilibrium, the practice has been to use ionization cross sections derived from the semi-empirical Lotz formula. Current research has shown that for ions in alkaline isoelectronic sequences the direct ionization process must have added to it inner shell excitation followed by autoionization and resonance recombination followed by double Auger autoionization.

Practically all of the cross sections and rates listed by the working groups as relevant are the same as previously reported. One exception is the need for diagnostics of alpha particles formed as a reaction product in deuterium-tritium plasmas operating at reactor-like conditions. With the copious production of alpha particles, the question arises as to whether the 3.5-MeV alpha particles will be lost from the confinement region by double electron capture collisions before transferring their energy to the plasma. D. Post has suggested that the velocity or energy distribution of the thermalizing alpha particles may be determined by injecting into the plasma a beam of He^0 or Li^0 at a few million electron volt energy and measuring the flux and energy of the escaping He^0 formed in the reaction $Li^0\ (He^0) + He^{++} \rightarrow Li^{++}(He^{++}) + He^0$. This diagnostic technique will require intense He^- or Li^- sources and knowledge of the relevant He^0 or Li^0 cross sections.

The reports of the working groups are a disappointment. No attempt was made to distinguish between data required or needed and the data base that exists at the present time. A summary of the status of the data in each area would add substantially to the proceedings. Twenty-three elements plus an unknown number of molecules are listed as requiring a large data base to satisfy the requirements of fusion. Without a large increase in support, such a task is improbable. One of the working groups assigned required accuracies of ±20% or a factor of 2 to the collisional data. The fact that the accuracy must be either ±20% or a factor of 2 implies that these limits are guesses, and they are misleading to the atomic physics community. Only when sensitivity computations are made for each process can a meaningful maximum error be assigned to a cross section or rate. For example, if radiation from an impurity contributes only a fraction of 10^{-5} of the total radiant energy, it is unnecessary to know the excitation cross section to within 20%. Throughout the proceedings, no report was presented of the theory and measurement of dielectronic recombination rates and cross sections except for the brief discussion by Dabau on satellite lines found in plasmas. Probably, this process is one of the most important interactions occurring in high-temperature plasmas and the omission is inexcusable. In summary, the meeting suffered from the proverbial theme of asking a 77-man committee to design an atomic physics program relevant to fusion.

Clarence F. Barnett began his career in Oak Ridge National Laboratory (ORNL) in 1943 as a technical advisor for the electromagnetic separation of uranium. From 1951 to 1956, he was engaged in studying the interaction of particles with gases and surfaces. Shortly after joining the fusion effort in 1956, he was made director of the DCX-1 mirror plasma project. His responsibilities during 1962 to 1979 included directing the atomic physics and plasma diagnostic groups and as director of the Atomic Data for Fusion Data Center. During these years, he was instrumental in establishing the American Physical Society (APS) topical conferences on atomic processes in high-temperature plasmas and high-temperature plasma diagnostics. He is a fellow of the APS and the American Association for Advancement of Science. At the present time, he is a senior scientist on the ORNL Physics Division staff.

Plasma Physics for Thermonuclear Fusion Reactors

Editor	G. Casini
Publisher	Harwood Academic Publishers P.O. Box 786 Cooper Station, New York, New York 10276
Pages	491
Price	$75.00
Reviewer	Robert A. Gross

This book is a compilation of lecture notes prepared by 11 European scientists for an introductory course on plasma physics. The course was given at the Joint Research Center of the Commission of the European Communities, Ispra, Italy Establishment, from October 1979 to January 1980. The purpose of the lectures and this book is to provide scientists and engineers who are working on technology problems of fusion with some basic information on plasma physics of controlled fusion. The material covered is nearly exclusively devoted to magnetic fusion, and in particular the tokamak confinement concept. The intellectual level of this material varies widely, but most of it should be understandable by scientists or engineers who have received good basic undergraduate training. The contents of this book are summarized in the following.

"Introduction into Fusion Plasma Physics" by F. Engelmann, from FOM-Instituut voor Plasmafysica, Rijnhuizen, Jutphaas, the Netherlands (16 pages, 16 references) is, apparently, a very shortened version of the introductory lectures given by the author. The deuterium-tritium fusion reaction is briefly described together with the physics requirements needed to achieve fusion power conditions. Magnetic confinement principles are sketched and fusion ignition is described. Some fusion reactor conditions are mentioned. There are no derivations. Results are stated, and in this very short introduction it is difficult to separate what is truly fundamental from what is empirical and subject to change.

"Features and Comparison of Magnetic and Inertial Confinement Reactors" by B. Brunelli from Fusione Centro di Frascati, Italy (33 pages, 7 references) summarizes very briefly what was presented in four lectures. In this chapter the author compares fission with fusion and inertial fusion with magnetic confinement concepts. There is some confusion between diffusion and conduction processes and the Lawson $\eta\tau$ criteria and ignition are discussed in a rather misleading way. This chapter is just too brief and is, consequently, very superficial.

"Plasma Equilibrium in a Tokamak" (22 pages, 10 references) and "Stability of a Tokamak Discharge" (21 pages, 12 references) by F. Troyon from Ecole Polytechnique Fédérale, Lausanne, Switzerland are a short and thoughtful introduction to tokamak equilibrium and stability theory. Careful definitions are used and selected results from ERATO and PEST computational codes are presented. The present limits to tokamak operation are discussed including disruptions, beta limits, and resistive instabilities.

"Transport and Scaling Laws in a Magnetized Plasma" by A. Nocentini, Instituto di Meccanica, Università degli Studi P. le Europa, Trieste (59 pages, 17 references) introduces magnetic confinement principles by considering the physics of plasma in a straight cylindrical magnetic field. Then plasma transport in tokamak toroidal geometry is qualitatively described. Neoclassical and anomolous transport are discussed using simple qualitative arguments. Pfirsch-Schlutter results are quantitatively developed, and weakly collisional plasma results are sketched. Some discussion is given of anomolous transport and scaling laws.

"Plasma Heating in Toroidal Magnetic Confinement Systems" by R. Gravier, Fontenay-aux-Roses, France (57 pages, 24 references) discusses ohmic heating in tokamaks, and anomolous losses observed in tokamak [Fontenay-aux-Roses (TFR)] experiments are considered in some detail. Additional heating methods using neutral beams and electromagnetic waves are briefly discussed. Technologies employed by these supplementary heating methods are described.

"Plasma Wall Interaction in Tokamaks" by J. Bohdansky from Max-Planck Institute, Garching, Germany (34 pages, 18 references) describes the physics of particle reflection and re-emission from surfaces. Additional phenomena of arc spots, sputtering, desorption, blistering, and particle recycling are discussed briefly.

"Divertor Problems" by P. J. Harbour from Culham Laboratory, England (41 pages, 71 references) briefly states the purpose and the history of divertors. Descriptions of different types of divertors are presented. Some examples together with experimental results from current tokamaks using divertors are described. A note added in proof states that some of the conclusions in this chapter have been recently revised.

"Main Features of Cold-Blanket Systems" by B. Lehnert from the Royal Institute of Technology, Stockholm, Sweden (81 pages, 127 references) describes the main features and the present level of understanding of a cool gas blanket between a hot plasma and a solid wall. The importance of this subject to tokamak physics is uncertain.

"Control of Burn-Up Phase" by A. Sestero from Frascati, Italy (17 pages, 7 references) presents a brief discussion of the elements of feedback control of an unstable ignition point in a tokamak.

"Turbulent Plasma Behavior in Toroidal Systems" by R. Gravier from Fontenay-aux-Roses, France (37 pages, 15 references) is a short and interesting survey of instability phenomena observed in tokamaks. The TFR data are used to describe tearing instabilities, island formations, Mirnov oscillations, sawtooth oscillations, and disruptions. The word "turbulent" in the title of this chapter is somewhat misleading.

"Plasma Transport Calculations for Fusion Reactors" by D. F. Düchs from Garching, Germany (46 pages, 5 references) describes important physical effects predicted by large-scale computer codes developed for tokamaks. Selected results from INTOR studies are presented. Numerical techniques and computer time needed for these studies are briefly described.

This reviewer found this book very heterogeneous, ranging from some very good sections to rather poor. It contains no index, and the notation and units in formulas varied throughout the text. The editor apparently made no effort to correct many spelling and grammatical errors. Particularly frustrating in some chapters was the failure to distinguish between fundamental physics and empirically observed tokamak limitations. This book can be compared with *Plasma Physics for Nuclear Fusion* by Kenro Miyamoto, MIT Press, 1980. The purpose of each book is similar. In the reviewer's opinion the text by Miyamoto is much superior.

Robert A. Gross did his undergraduate study in engineering at the University of Pennsylvania and received his doctorate in applied physics from Harvard University. He then worked in the aerospace industry for six years, principally on research in high-temperature gas dynamics and supersonic combustion. In 1959 he was a senior National Science Foundation Fellow at the University of California, Berkeley and the Lawrence Livermore National Laboratory. In 1960 he was appointed professor at Columbia University where he founded its plasma physics laboratory. His research since then has been primarily concerned with the physics of very strong shock waves and the physics of high-beta tokamaks. He holds the Percy and Vida Hudson Chair of Applied Physics at Columbia University and in 1982 he was appointed Dean of the School of Engineering and Applied Science.

A Desirable Energy Future: A National Perspective

Authors	Robert S. Livingston, Truman D. Anderson, Theodore M. Besmann, Mitchell Olszewski, Alfred M. Perry, and Colin D. West
Publisher	The Franklin Institute Press, 20th and The Parkway, Box 2266 Philadelphia, Pennsylvania 19103
Pages	262
Price	$24.50 hardbound
Reviewer	William C. Gough

The goal of *A Desirable Energy Future: A National Perspective* is to develop an independent viewpoint to aid the planning of energy R&D. The authors did not attempt to predict the future based on theoretical and empirical data, for example, by use of large computer-based models. Rather, they assumed a desirable future and then examined