

Book review

Tokamaks—Third Edition

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John Wesson's well known book, now re-edited for the third time, provides an excellent introduction to fusion oriented plasma physics in tokamaks. The author's task was a very challenging one, for a confined plasma is a complex system characterised by a variety of dimensionless parameters and its properties change qualitatively when certain threshold values are reached in this multi-parameter space. As a consequence, theoretical description is required at different levels, which are complementary: particle orbits, kinetic and fluid descriptions, but also intuitive and empirical approaches. Theory must be carried out on many fronts: equilibrium, instabilities, heating, transport etc. Since the properties of the confined plasma depend on the boundary conditions, the physics of plasmas along open magnetic field lines and plasma surface interaction processes must also be accounted for.

Those subjects (and others) are discussed in depth in chapters 2–9. Chapter 1 mostly deals with ignition requirements and the tokamak concept, while chapter 14 provides a list of useful relations: differential operators, collision times, characteristic lengths and frequencies, expressions for the neoclassical resistivity and heat conduction, the bootstrap current etc.

The presentation is sufficiently broad and thorough that specialists within tokamak research can either pick useful and up-to-date information or find an authoritative introduction into other areas of the subject. It is also clear and concise so that it should provide an attractive and accurate initiation for those wishing to enter the field and for outsiders who would like to understand the concepts and be informed about the goals and challenges on the horizon. Validation of theoretical models requires adequately resolved experimental data for the various equilibrium profiles (clearly a challenge in the vicinity of transport barriers) and the fluctuations to which instabilities give rise. Chapter 10 is therefore devoted to an introduction to diagnostics for tokamaks.

The complexity of fusion plasmas is attested to by the discovery of new phenomena and

new operational regimes as machine size and power increased and the diagnostic tools improved over the forty years of research on magnetic confinement. The history of those discoveries in the devices which have been built worldwide after the results obtained on the first tokamaks at the Kurchatov Institute had been confirmed is outlined in chapters 11–12. Particular emphasis is naturally given to the results from the larger tokamaks: ASDEX Upgrade, DIII-D, TFTR, JT-60/JT-60U and JET. Chapter 13 is devoted to the International Tokamak Experimental Reactor and prospects beyond ITER. Examples of operational regimes and of often unexpected phenomena are the linear and saturated ohmic confinement modes, confinement degradation when auxiliary heating is applied, the high energy confinement mode, the formation of internal transport barriers in weak or negative central shear discharges, sawtooth relaxations, disruptions, multifaceted asymmetric radiation from the edge, edge localised modes, etc. The relevant observations are described very thoroughly with the support of numerous selected figures and their physical interpretation, a major topic of the book, is carefully discussed on the basis of simplified but convincing mathematical models.

With respect to the previous edition (1997), a few additions have been introduced; those concern plasma rotation (Section 3.13), internal transport barriers (4.14), the role of radial electric field shear (4.19), turbulence simulations (4.21), impurity transport (4.22) and neoclassical drive of tearing modes (7.3). It is my personal feeling that some of those additions should have been somewhat more elaborated. A few pages have finally been added concerning the TCV, START, MAST, NSTX and ASDEX Upgrade tokamaks.

With this book, John Wesson offers the fusion community a very precious and thorough survey of tokamak physics, from basic principles to interpretation of experimental data, and to a wider readership an elegant and authoritative introduction to the challenges that are associated with the development of the tokamak reactor, a source of limitless and clean thermonuclear power. This reference book should be on the shelf of every fusion scientist and graduate student.

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