Preface

Tokamak reactors pose a myriad of interesting control challenges that have been tackled (with more or less success) over the past few decades. However, until recently, most of the control objectives were formulated in terms of one or a few scalar parameters or quantities (such as the plasma position, shape, total plasma current, etc.). In the last few years, more complex control problems, involving spatially distributed quantities (such as the plasma current density, temperature, magnetic field, etc.) that also evolve in time (and are thus represented by partial differential equations) have begun to appear in the literature. One of such problems is the control of the safety factor profile in a tokamak. This book presents a series of techniques and new methods applied to this control problem.

Although some results presented in this book are based on a series of articles by the authors, a great deal of effort was made to present them as a coherent body of work, as opposed to individual self-contained results, showing the logical progression of the research carried by the authors. Since this book should be accessible to the widest possible audience, we have opted to provide only sketches of proofs whenever possible in order to give to the reader the possibility to understand the main concepts without reducing the readability of the content.

In Chap. 1, we present a brief introduction to the control of thermonuclear fusion and highlight the interest of regulating the safety factor. A detailed explanation of the distributed reference model is provided in Chap. 2, as well as a general statement of the control problem and its main technical difficulties. A finite-dimensional control approach is proposed in Chap. 3, after discretizing the partial differential equations that model the poloidal magnetic flux evolution. The partial fulfillment of the control objectives obtained with this approach motivates the distributed approach that is followed in the rest of the book. Chapter 4 details the main theoretical results necessary for developing a distributed control law that can take into account space and time-variations of the transport parameters, together with some simulation results on a control-oriented simulator. Finally, Chap. 5 presents some extensions required for implementing the proposed scheme on a realistic scenario, along with simulation results on more complex, physics-oriented codes.

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