# BOOK REVIEWS

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

**Inertial Confinement Fusion**

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| *Authors* | James J. Duderstadt and Gregory A. Moses |
| *Publisher* | John Wiley & Sons, New York (1982) |
| *Pages* | 347 |
| *Price* | $48.50 |
| *Reviewer* | Glenn R. Magelssen |

To my knowledge this is the first textbook to attempt to present an introduction to all aspects of inertial confinement fusion (ICF). General target physics and design, driver and driver/target interaction physics, as well as reactor technology, are included. Furthermore, both laser and particle drivers are considered.

The orientation of the book is useful and logical. In an effort to keep the development of ICF concepts as independent of the driver as possible, thermonuclear burn, hydrodynamic implosion and compression, and energy transfer in dense plasmas are presented first. Driver energy deposition is then considered. The text is flexible enough to be used in several types of courses. If additional quantitative material were used to supplement the text, a course on the general physics of ICF, a course on driver/target physics and target design, or a course on driver physics and reactor technology would be feasible.

The authors state in the Preface that the book is aimed at advanced undergraduate or graduate students in engineering and physics, as well as at practicing engineers and scientists seeking an introduction to ICF. It is my opinion that the treatment is somewhat advanced for an undergraduate course, but is a very good introduction to ICF for the practicing engineer and scientist. It could be used as a textbook for a graduate course. However, because of the broad scope of the book, most physics areas are not covered in depth and supplemental material might be necessary to make a particular physics section complete. Also, no problems are given at the end of a chapter and none are suggested in the text.

The physics of ICF is quite complex and at times the authors fail to give a clear understanding of the limitations of the physical models they present or insight into what research directions need to be pursued. It also would have been helpful to have had examples of how different physical models impact target behavior.

The book is composed of ten chapters beginning with an introduction to basic ICF concepts and ending with a chapter on ICF applications. The introduction is quite good. Every driver option currently being considered is described, the basic ICF concepts clearly presented, and an overview of the U.S. program given. Thermonuclear burn physics is the topic of Chap. 2. The nuclear reactions being considered for ICF applications are examined. The deuterium-tritium, deuterium-deuterium, and $PB^{11}$ burn cycles are discussed. The basic guiding principles behind high gain are clearly presented. In Chap. 3 there is a good presentation about the need for isentropic compression and the failure of strong shocks to achieve adequate compression for ICF purposes. Ablation acceleration concepts are introduced and examples given. Unfortunately, hydrodynamic stability and symmetry issues are given a very brief treatment. Also, equation-of-state physics is not presented in any depth. For example, such high-density effects as pressure ionization are not discussed. In Chap. 4 a general treatment of thermal conduction is given and target corona-core decoupling is described. Experimental results suggesting thermal conduction inhibition in laser-irradiated targets are given as well as a variety of theoretical suggestions for this inhibition. Radiative physics and transport are introduced toward the end of the chapter, but the discussion is brief. Chapter 5 treats the beam-target interaction physics. All the different laser/plasma coupling processes are clearly presented and the linear growth rates given. However, questions concerning the effect the ponderomotive force plays in calculating the linear growth rates are not explored. Also, although the discussion implies that anomalous absorption at the critical density creates hot electrons, the actual electron acceleration is not described. There is a brief discussion on the electron range in matter, and a more extensive section on ion slowing down. The classical slowing down of ions, including the Bethe and Linhard formulas, is presented. Comments on the effective charge of an energic ion in a plasma are not clear. A discussion on the validity of the classical theory of ion stopping is somewhat misleading. The screening of the high-energy ions will be from the nonthermal component of the background plasma not the thermal component, and the corona background electron density could be as low as $10^{17}$ $cm^{-3}$. Chapter 6 contains a very good discussion of the difficulty of numerically modeling ICF physics. A finite difference approach to solving the hydrodynamic equations is presented. Particle-tracking methods and multigroup diffusion techniques are discussed. A brief treatment of the numerical methods for studying plasma kinetics is presented. For example, the particle-in-cell technique is illustrated. Laser and particle driver physics and design are explored in Chaps. 7 and 8, respectively.

A clear description of the physics of how a laser works is given. The problems of current ICF laser drivers and the

proposed advanced drivers are topics of consideration. The physics of pulsed power diode accelerators (i.e., the light-ion approach to fusion) is described in some detail. However, the physics of particle accelerators (i.e., the heavy-ion approach to fusion) is very brief. Target design, fabrication, and diagnostics are examined in Chap. 9. The section on general guidelines for target design is useful and informative. Examples of both laser and ion targets are illustrated. The sections on target fabricability and diagnostics could have been more informative. Chapter 10 is concerned with applications of ICF. The authors purposely concentrate on energy applications. A good overview of ICF reactors is given. The overview includes reactor cavity designs, blanket designs, beam optics, fusion-fission hybrids, and an overall laser fusion plant design.

The writing is clear and easy to read and tables and figures have been carefully selected to illustrate the points to be made. The authors have made a special effort to present simple analogies to help in the understanding of a concept. For example, in the introduction, a comparison is made between the inertial confinement reactor and the internal combustion engine. The extensive reference list at the end of each chapter is a useful tool for the person who wishes to pursue a subject in depth. The book contains more than 600 references.

In summary, this book is an exceptionally well-written, up-to-date, introductory text to ICF that is suitable for self-study or as a graduate text. The coverage may lack depth in some areas, but the breadth and variety of topics overcome this disadvantage so that the interested person could pursue specific areas of interest.

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**Physics of Laser Driven Plasmas**

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| *Author* | Heinrich Hora |
| *Publisher* | John Wiley & Sons, New York (1981) |
| *Pages* | 317 |
| *Price* | $36.95 |
| *Reviewer* | Peter Hammerling |

The subject of laser/plasma interaction, particularly within the context of laser fusion, is a very rich one. It starts with the basic interaction of the absorption, reflection, and refraction of the incident laser beam including the possible excitation of a host of plasma instabilities. The energy is then transported both radially and laterally outside the confines of the immediate deposition region. Radiation losses and their mechanisms of generation and transport also must be considered, as must the hydrodynamics of the ablation process, the hydrodynamic stability of the target and, for a spherical shell target, its subsequent motion toward the center. In principle, the interaction spans the noncollisional regime of the outer corona to, eventually, a nearly degenerate high-density plasma.

In view of the considerable effort expended in the study of the interaction between lasers and plasmas, a good monograph on this subject would be a welcome addition to the literature. This, unfortunately, is not such. Although Hora's work does cover many important aspects of laser/plasma interaction, it does so from a point of view original to the point of eccentricity, and contains a great deal to be disagreed with. The level of the work is never very clear, parts of it are elementary, parts of it are rather formidable. It appears to be aimed both at the newcomer to the subject who is interested in finding a coherent statement of the fundamentals as well as, in the last chapter, to the laser/plasma interaction community. The treatment of plasma dynamics is not very happy: There is an original interpretation of the role of plasmas with which few could agree. To a great extent he uses a simple hydrodynamic description, and even here, produces an energy equation that would raise some eyebrows!

The author does give a fairly complete treatment of the transmission and absorption of radiation in a spatially variable medium, although since it is confined to a one-dimensional spatial variation, this omits the entire subject of geometric optics. The longitudinal component of the field is also included at this level but resonant absorption is treated in a separate section.

Given the title, one might expect a fairly detailed treatment of anomalous absorption and scattering processes, but these are treated in a very perfunctory fashion. As might be expected, there is a fairly complete treatment of the origin of the ponderomotive force (although even here, some important references are not included), and its consequences in cavitation, filamentation, and so forth. In the last chapter, Hora suggests that the ponderomotive force from an extremely high-powered beam might tend to accelerate and compress a pellet to thermonuclear burn—clearly his central interest. This disagrees with the general opinion that at high-power levels the rapid forward heat transport by high-energy nonthermal electrons prevents adiabatic compression and disastrously raises energy thresholds. Indeed, perhaps because of this bias, the key topics of heat transport and hydrodynamic stability are not even mentioned.

This work cannot be recommended to those seeking an introduction to the field; however, representing as it does an extremely original view of the subject, it might be of interest to the cognoscente who may be prepared to put up with an idiosyncratic approach in the search for the occasional original insights.

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