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BOOK REVIEW

Combustion Physics. By CHUNG K. LAW. Cambridge University Press, 2006. 738 pp. ISBN 0521 870526. £55.

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Combustion is not a sub-topic within the field of fluid mechanics per se, but rather fluid motion is just one of the possibly important processes in any given combustion problem. The fluid dynamics are then nonlinearly coupled to thermo-chemistry. Hence, a combustion scientist needs a good background not only in fluid mechanics (including, for many real world applications, turbulence), but also in chemistry and chemical kinetics, thermodynamics and heat and mass transfer, and in how these different processes interact. Combustion processes are not only highly nonlinear but also typically highly multi-scale, even for laminar situations, making combustion theory and numerical simulation challenging (although the multi-scale nature can be exploited by asymptotic analyses in the simplest problems). On the other hand, experimentally observing combustion phenomena (via optical or laser diagnostic methods) becomes increasing difficult and expensive as one moves towards the high pressures and temperatures which occur in real applications, such as engines. The modelling and experimental challenges are of course greatly compounded for turbulent combustion processes. Hence a graduate student working in the area needs to become versed not only in the broad range of topics outlined above, but also in state-of-the-art numerical methods and/or experimental techniques and equipment.

The stated purpose of the book is as a graduate level text, and it succeeds in this very well. While I would not recommend the book for bed-time reading or that it is even read in a linear fashion (indeed, the first two chapters on thermodynamics and law of mass action are rather dry and may deter the casual reader – these chapters would have benefited from more worked examples), its strength is as a hand-book or reference text. It is a very complete book on the subject, with each of the mostly self-contained chapters giving a good background to various aspects of combustion. The introduction to these chapters also contains references to other and more specialized texts on a particular subject, if the reader is interested in delving further into the details. The topics are explained and illustrated via an instructive combination of theoretical, numerical and experimental results. One can therefore envisage a graduate student working on combustion problems keeping the book close at hand, and frequently referring to parts of it throughout his or her studies.

The completeness of the book is demonstrated by the breadth of the topics covered. The earlier chapters take the form of monographs on fundamental topics including: oxidation mechanisms of hydrogen and hydrocarbon fuels and methods for reduction of kinetic mechanisms; transport phenomena (heat conduction, mass diffusion and viscous motion); the derivation of the complete governing equations (cast in conservation form) together with common simplifying approximations; laminar 'diffusion' and premixed flames with application of asymptotic methods; limit phenomena (ignition, extinction and flammability limits); effect of stretch on flames (flame wrinkling and curvature, flow straining) including intrinsic cellular, hydrodynamic and pulsating instabilities. The final chapters of the book are on

advanced subjects such as turbulent combustion, including techniques and closure issues of modelling variable-density reactive turbulent flows and the different modes of turbulent combustion, and combustion in boundary layers and in two-phase flows (including droplet and spray combustion).

The book ends with a chapter on supersonic combustion (blast and detonation waves). Thus, as is typically the case in books on combustion, high-speed reactive flows are treated as an aside or a small sub-topic. This is not to my taste, since as much could be written as for low-speed combustion (e.g. detonation propagation and instabilities, ignition and failure of high-speed combustion waves, very high pressure chemistry, detonation and initiation of solid and liquid explosives, etc). Indeed, a complete volume on high-speed combustion in a similar style to the book under discussion would be most welcome and timely; the main graduate level text on this subject is still the excellent book *Detonation* by W. Ficket & W. C. Davis (Dover, 1979), despite three decades of advancements since its publication.

The book does have a couple of potential shortcomings as a graduate level text. First, many of the topics are presented as standard or completed areas (the chapter on turbulent combustion is a notable exception). Some indication of what the open problems or 'grand challenges' are in each topic would have been appropriate for a book aimed at graduate students. Some research frontiers are mentioned briefly in the introduction. For example, in the foreseeable future, combustion research is likely to be driven by the need for alternative fuels (e.g. biofuels and, in the longer term, hydrogen) due to supply and emissions/pollution issues. However these research challenges are then not put clearly into context in the subsequent chapters. Secondly, the bibliography is some what self-referential and biased. Some of the main non-US groups do not even get a mention. Hence graduate students using the book as a reference text will not be exposed to the full range of research, nor will they be exposed to opposing views or various scientific debates. Nevertheless, given the completeness, scope and style of the book, these are minor criticisms, and I will certainly be recommending 'Combustion Physics' to graduate students working in this area.

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