EXTREME PHYSICS

Properties and behavior of matter at extreme conditions

Most matter in the Universe, from the deep interior of planets to the matter of stars, is at a high temperature or a high pressure compared with the matter of our ordinary experience. This book offers a comprehensive introduction to the basic physical theory on matter at such extreme conditions and the mathematical modeling techniques involved in numerical simulations of its properties and behavior.

Focusing on computational modeling, the book discusses topics such as the basic properties of dense plasmas; ionization physics; the physical mechanisms by which laser light is absorbed in matter; radiation transport in matter; the basics of hydrodynamics and shock-wave formation and propagation; and numerical simulation of radiation-hydrodynamics phenomenology. End-of-chapter exercises allow readers to test their understanding of the material and introduce additional physics, making this an invaluable resource for researchers and graduate students in this broad and interdisciplinary area of physics.

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CAMBRIDGE
UNIVERSITY PRESS

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University Printing House, Cambridge CB2 8BS, United Kingdom

Published in the United States of America by Cambridge University Press, New York

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781107019676

First published 2014

Printed in the United Kingdom by TJ International Ltd. Padstow Cornwall

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data
Colvin, Jeff, 1945–
Extreme physics : properties and behavior of matter at extreme conditions / Jeff Colvin, Lawrence Livermore National Laboratory, Jon Larsen, Cascade Applied Sciences, Inc.
pages cm
Includes bibliographical references and index.
ISBN 978-1-107-01967-6 (hardback)
1. High pressure physics. 2. Matter – Properties. 3. Physics – Mathematical models. I. Larsen, Jon, 1942– II. Title.
QC280.2.C65 2013
539.7′6 – dc23 2013013778

ISBN 978-1-107-01967-6 Hardback

Contents

Acknowledgments

This book grew out of a short course we have been teaching on an irregular basis to graduate students and post-doctoral staff at the Lawrence Livermore National Laboratory (LLNL) in Livermore, CA where one of us (JC) is a staff scientist. The other (JL) is a consultant to LLNL – as well as other national laboratories and many universities – to support the radiation-hydrodynamics computer codes (HYADES and h2d) that he developed. The course we put together consists of "tutorials," in which we teach the basic physics on which radiation-hydrodynamics modeling and computations is based, and a "practicum," in which the students gain some hands-on experience in how to do computations. The course content was pieced together from our own notes and from a number of published sources, and the content grew and evolved over the years. Occasionally, a career LLNL staff scientist would enroll in our course. The original suggestion to turn our course notes into a textbook came from one of these staff scientists who took the course, Hector Lorenzana. We are very grateful to Hector for this suggestion.

We are also very grateful for the competent review and critique of an early draft of the text that was done by Bill Varnum, formerly of Los Alamos National Laboratory (LANL). Bill's comments led to some restructuring and some substantive revisions, which we believe has improved the text considerably. We take full responsibility for any remaining errors and deficiencies.

Just getting to the point of being able to write such a text required many years of "on-the-job" learning of all the relevant physics and computational techniques. Until now, there has not been a single text that brings all the relevant material together in one place. Accordingly, our professional interactions with colleagues over the years have been invaluable in our own education.

One of us (JC) would like to acknowledge, in particular, the many fruitful discussions and collaborations with the following people, some of whom are now retired or moved elsewhere. At LANL: Stirling Colgate, Ricky Faehl, Frank Harlow, Alan Hauer, Nelson Hoffman, George Kyrala, Dennis Paisley, the late Al Petschek, Bill

Varnum, Bob Watt, and Douglas Wilson. At LLNL: Peter Amendt, John Castor, Guy Dimonte (now at LANL), Kevin Fournier, Steve Haan, Judy Harte, Warren Hsing, Bob Kauffman, Joe Kilkenny, Wayne King, Bill Kruer, Mukul Kumar, John Lindl, Karnig Mikaelian, Roger Minich, Steve Pollaine, Bruce Remington, Mordy Rosen, James Stolken, Larry Suter, Bob Tipton, Steve Weber, and George Zimmerman; Todd Ditmire at University of Texas, Austin; Paul Drake at University of Michigan; Jim Asay, Rick Olson, and John Porter at Sandia National Laboratories, Albuquerque; Justin Wark at Oxford University; Michel Legrand at CEA (France); Brian Thomas at AWE (UK); and Ivan Lebo at the Lebedev Institute (Russia).

One of us (JL) would like to acknowledge, in addition to many of those individuals listed above, some of his colleagues from his tenure at KMS Fusion; in particular, Roy Johnson, Fred Mayer, Phil Campbell, Alex Glass, Walter Fechner, Joe McGrath, and Linda Powers. He also wishes to extend special thanks to John Nuckolls who brought him into the field of radiation hydrodynamics.

We undoubtedly neglected to mention by name some people who should be acknowledged here. For any such oversights we sincerely apologize.

Of course, we owe a big debt of gratitude to all our students over the years, almost all of whom posed insightful questions and made thoughtful comments that helped in the evolution of the course material. We also thank Todd Ditmire for sending to us a few of his students from the University of Texas, Austin to attend the course at LLNL.

We owe a special debt of gratitude to Bruce Remington of LLNL. Over the course of many years Bruce provided both of us with help, encouragement, and guidance in our work. Most importantly, he originated the idea of our short course from which this book evolved, and provided the initial support that brought the two of us together to develop and teach the course.

Steve Lane and Bruce Remington, both of LLNL, offered early encouragement and support to one of us (JL) to write an easy-to-use hydrodynamics code, one that approached the topic from the point of view of an experimentalist. Thus began the quarter-century effort to develop the one-dimensional radiation-hydrodynamics code HYADES, as well as the two-dimensional version h2d. Information about these simulation codes may be found at http://www.casinc.com. Significant portions of this text and selected figures are derived from the HYADES documentation: *Book II, The Physics in HYADES* and an expanded edition of that work, *Foundations of High-Energy Density Physics*. The material used herein is made available under a copyright agreement with Cambridge University Press.

One of us (JC) would like to thank LLNL management for making it possible to take leave to work on this book. Much of the writing while away from LLNL was done while in Gettysburg, PA and JC would like to thank Tim Good at Gettysburg

College for the appointment as a Fellow of the College and for providing such a welcoming atmosphere in the Physics Department there.

We also thank our families for their understanding and forbearance as we missed countless family functions while focused on the writing of this book.

Finally, we would like to acknowledge our editor at Cambridge University Press, Simon Capelin, and his assistants, Zoë Pruce and Kirsten Bot. Without their able guidance and assistance this book would not have been possible.