The spawning of the new field of Bose–Einstein condensation of atomic gases, the awarding of the 1997 Nobel Prize in Physics for laser cooling, and the advent of extensive applications, including the incorporation of laser cooling into the fundamental time standard, and plans to put cold, trapped atoms into space, have all contributed to a changed perspective. The field is established; why isn't there a textbook?

There has certainly been a need: Students entering the field must first understand a core of specialized atomic theory. Then they are faced with the impressive number of ways the theory has been applied to achieve mechanical control over atoms. For instance, the widely known Doppler cooling technique is but one of roughly a dozen distinct laser cooling mechanisms that have been demonstrated. Similarly, there are more than a score of variants on magnetic, optical, and electric field atom traps and a comparable number of atom optical elements. It is a lot to pick out of primary sources without a guide. Hal Metcalf and Peter van der Straten's *Laser Cooling and Trapping* provides the guide.

Laser Cooling and Trapping is divided into three parts. The first part is an introduction that summarizes general physics relevant to cooling and trapping. It presents the background topics a student must understand to read the cooling and trapping literature. I find it remarkable that, besides being thorough, it contains essentially no extraneous topics. Despite what must have been a strong temptation to give a little more background here and there, the introduction is consistently on message. Most of its space is used to discuss two-level atoms, optical Bloch equations, and light–atom interactions. The brief discussion of atomic structure is just what you need to know for most laser cooling. The miniprimer on thermodynamics hits only those concepts that tend to crop up in cooling and trapping, such as random walks, the Fokker–Planck equation, and Liouville's theorem. In all, the material in this introduction would typically be gleaned from at least four different texts. It's nice to have it all in one place. Although the discussions in the book are self-contained, students will often need to supplement them with more specialized texts. I think that a chapter-by-chapter annotated bibliography would significantly help students to use the extensive array of references.

The next two parts discuss cooling and trapping and their applications. This array of experiments and technologies is special, in that most of the physical phenomena are exactly calculable. Everything comes down to electromagnetic fields interacting with atoms, or atoms interacting with each other at low energy. Experimental situations may get complicated, but the complete Hamiltonians are known, and the equations of motion can usually be solved.

The book provides the framework for understanding this aspect of laser cooling, but does not dwell on it. Instead, the authors usually opt for simple models and pictorial explanations. Much of the time, cold atoms are batted around by fields as if they were little balls, or they are ideal wavefunctions navigating textbook potentials. And it was the right approach for the authors to take. This flavor of explanation is common in the field, allowing the introduction of a huge range of techniques and applications. Most important: Students should find this approach to physics compelling.

I would be somewhat uneasy if *Laser Cooling and Trapping*, despite its protestations to the contrary, comes to be viewed as a definitive, archival review of past work. It may take on this cast because it does cover so much ground, but the book is not complete; it leaves out some relevant work of comparable importance. Further, the explicit mention of names of scientists and institutions in the text is rather erratic. But for its intended use, which is to guide newcomers into the field of laser cooling and trapping, the book does a superb job. It is organized so as to facilitate updates and additions, and even now, developments since the text was written could probably extend the book by half. Accordingly, I look forward to the second edition. This book is well placed to evolve with the field for many years to come.

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Reduced Density Matrices: Coulson's Challenge

A. J. Coleman and V. I. Yukalov
Springer-Verlag, New York, 2000. $69.80 paper (282 pp.). ISBN 3-540-67148-X

In a 1959 after-dinner speech at a conference on molecular quantum mechanics held at the University of Colorado, the late Charles Coulson reviewed the state of molecular-structure calculations. Among the topics he discussed was the feeling that a conventional many-electron wavefunction tells us more than we need to know. For energy calculations involving one-electron and two-electron interactions, the equivalence of all the electrons in an N-electron system allows a particular pair of electrons to be selected for study, while integration over the coordinates of the remaining $N-2$ electrons removes them from the analysis. This procedure amounts to a construction of the pth-order reduced-density matrix (RDM) with $p = 2$ for the two selected electrons. In terms of these, all calculations of physical quantities can be made. The problem is that, whereas it is straightforward to construct the RDM, given the wavefunction, it is not obvious what conditions the RDM itself should satisfy. These would be needed if the RDM were to replace the wavefunction as the basis for a calculation. The way forward was not obvious to Coulson.

John Coleman was stimulated to take up the challenge set by Coulson, that is, to make the RDM the basic starting point for all molecular calculations. In doing so, he established a very active group at Queen's University in Kingston, Ontario. The book under review represents an account of the progress that has been made in the past 40 years, principally from Coleman's perspective. Coleman is joined as co-author by Vyacheslav Yukalov, from the Joint Institute for Nuclear Research in Dubna, Russia, whose collaboration with him on RDM work dates from 1990. The reader's appetite is whetted by the publisher's note on the cover of the book, as well as by the authors' comments in the preface, that there are now algorithms that make it possible to calculate "nearly all the properties of matter which are of interest to chemists and physicists." To bring the reader to that point, the authors set out the steps taken along the way.

The key problem is to ensure N-representability, that is, to impose fermionic conditions on the RDM appropriate to a wavefunction describing the N-electron system. In discussing this difficulty, the authors adopt a rather formal mathematical style, as well as a specialized vocabulary that reflects the long development of the field. This seems somewhat inappropriate for a text designed (as they say) for first- or second-year graduate students. One wonders how Coulson, whose writing was a model of transparency, would have reacted to it. To get started, students may prefer *Density Functional Theory of Atoms and Molecules*, by Robert G. Parr and Weitao Yang

(Oxford U. Press, 1989).

Despite its use of specialized vocabulary, *Reduced Density Matrices* has the great advantage of bringing the subject up to the present. Its final section tells an exciting story: Coleman and Yukalov argue that the extreme practitioners of density functional theory, who aim to go beyond RDM theory and eliminate everything but the electron density as an input to their calculations, are whistling in the dark. They see the future presaged in the work of Carmela Valdemoro, Hiroshi Nakatsuji, Koji Yasuda, and David Mazziotti, who base their work on the demand that a recurrence relation between RDMs of orders p, $p+1$, and $p+2$ be self-consistent, thereby guaranteeing N-representability. Their results for the ground-state energies of light atoms like beryllium and neon and small molecules like H_2O, NH_3, and CH_3F, are competitive with values obtained by traditional multiconfigurational Hartree–Fock methods in which the wavefunction plays the central role.

The numerical comparisons are impressive: Agreements to four or five significant figures are common. However, to learn of these remarkable results, the reader is urged merely to turn to articles in the literature. The book would have gained from a detailed comparison of the two theoretical methods, but there is no doubt that the authors have achieved their goal of describing how Coulson's challenge can be met.

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Rutherford: Scientist Supreme

John Campbell
AAS Publications, Christchurch, New Zealand, 1999. $40.00 (516 pp.). ISBN 0-473-05700-X

John Campbell's biography of Ernest Rutherford—who may surely be designated as New Zealand's greatest son—is unquestionably a labor of love, of steadfast devotion on the part of a loyal, energetic, and enterprising physicist who shares with Rutherford both New Zealand birth and Scottish descent. Campbell, has for many years been teaching physics at Canterbury College in Christchurch, New Zealand, the college at which Rutherford studied and worked from 1890 to 1895.

The purpose of this biography, as Campbell explains, is to redress "New Zealand's tremendous disservice to [Rutherford]" in its presentation of an incorrect and inadequate image of him—one with which "no New Zealand children can identify." This lack is not surprising, because not one of the several dozen biographical works on Rutherford had been written by a New Zealander. Campbell has now corrected this lapse—and also, he hopes, other errors of both omission and commission in the Rutherford legacy.

In this context, it is not surprising to find about half of Campbell's book devoted to the first 24 years of Rutherford's life (1871–95), which were spent in New Zealand. The remaining half covers 40-plus years of his great scientific career in Cambridge, England; Montreal, Canada; Manchester, England; and Cambridge (again). Campbell invariably relates even this latter part to a New Zealand context; indeed, few of the 400 or so textual pages lack *some* reference or relationship to New Zealand.

Campbell's biography is the result of more than two decades of assiduous research: collecting and recovering records, interviewing relatives or descendents of relatives, and scrutinizing hearsay and legends. All is fully and faithfully displayed and recorded, with a wealth of illustrations of people, laboratories, artifacts, tokens, and medals.

The geographical, social, and economic background of a relatively raw and far-distant colony in the 19th century and, more specifically, the background of Rutherford's forebears, family, childhood, and early education all emerge vividly in this biography. They heighten the great drama of a youth from a remote frontier transposed to the opposite part of the globe, to emerge with astonishing speed as one of the world's greatest scientists. As a fellow student observed soon after Rutherford's arrival at Cambridge: "We've got a rabbit here from the Antipodes, and he's burrowing mighty deeply."

Despite the very limited resources of Canterbury College, it was in New Zealand that Rutherford first demonstrated his ability to make the most of any and every opportunity. So when he arrived in the scientific world of Cambridge—Trinity College and the Cavendish Laboratory—he already had considerable experience and accomplishment in the newly opened field of the production and detection of "Hertzian" waves. Rutherford's work on this topic, more demonstrative of scientific enthusiasm, insight, and perseverance than of precocity, is the essential bridge linking two major phases of Rutherford's life. It is fully presented in Campbell's account, but in personal rather than scientific terms.

To remind us that we are dealing close-up with one whose childhood was shared with 11 siblings and many dozen first cousins, whose most devoted, lifelong relationship was with his mother (of little formal education), and who became a scientist of unique eminence, Campbell invariably refers to Rutherford as "Ern." He does not use Rutherford's formal title Lord Rutherford of Nelson; or Sir Ernest (he was knighted in 1911); or "the Prof," as he was known to countless disciples and students at Montreal, Manchester, and Cambridge; or simply as Rutherford, as his name appeared in the scientific literature. He was simply "Ern."

The second half of this book can deal only briefly with the highlights of a career covering more than 40 years. Campbell tries to keep Ern, the person, closely in view at all times. Indeed, he reminds us that, despite the great shifts of locale and personal and professional growth, Rutherford's vigorous personality is recognizable and unchanged always.

Rutherford was not a particularly modest person. ("He had so little to be modest about!") He did recognize his debt to his forebears and to opportunity; at a youthful age, he had composed an essay on the topic of the relative importance of inheritance, education, and experience. But later, at the height of his career, when a colleague commented that he was fortunate "to have ridden such a powerful wave" of science, Rutherford retorted, "Well, I made the wave myself, didn't I?"

Campbell addresses his writing to the youth of New Zealand, but there is much here to interest and intrigue those of other generations and from other parts of the world. It is enlightening to observe that, in such a different social milieu and more than a century ago, there were serious concerns about how science might be taught and debates about its social role. And it is illuminating and challenging in this age of "multiple choice" to read the examination questions set at Canterbury College.

This book contains intriguing details. Where else could one learn that Rutherford (Ern) was not aware of his correct name (Ernest) until age 24 when, on his departure from New Zealand, he had to produce his birth certificate? Or that the news that he had received the Nobel Prize in Chemistry in November 1908 had to compete (unfavorably) in the *Nelson Evening Mail* with the more eagerly awaited news about the result of the 34th week of the Nelson Poultry Association's egg-laying competition?