implantation into various forms of carbon. The book commences with a rapid summary of the properties of the various allotropes of carbon ranging from the extremes of graphite to diamond, together with the attempts to form glassy carbon, fibres and diamond-like carbon films (which contain hydrogen). Subsequent chapters very rapidly introduce the subject of ion implantation and a variety of analytical techniques. These five introductory chapters are somewhat superficial, which is inevitable considering the scope they attempt to cover. For the newcomer to the field there are a reasonably extensive set of standard references to help expand the material.

The authors then present a chapter on each of the various forms of carbon which have been modified by ion beam implanatation. Whilst the implantation damage in graphite may be controlled, or thermally removed, this is obviously much more difficult at the other end of the scale, for diamond. Consequently the modifications to diamond are spectacular for say electrical conductivity as the insulator is converted into a conductor. The conduction process is not solely graphitization and various models are discussed.

Familiar implantation effects on hardness, volume, anisotropic distortion, optical colouration, infrared vibrations, etc. have been monitored in most of the carbon allotropes and the book catalogues these changes. Once again there are additional references provided to follow through for detailed consideration.

Obviously one interest in ion implantation in diamond is to generate semiconducting properties in a wide gap material. Some natural diamonds contain impurities which offer p or n type conductivity, but so far the addition of impurities by implantation has proved extremely difficult, and all the results are at the level of academic curiosity rather than offering any real hope of device fabrication.

Overall the book encompasses the major implantation results for diamond and the related structures, etc. and thus provides a sound review of the topic. However, the readers should note that much is still to be learnt and applications are only a distant desire.

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Lectures on Phase Transitions and the Renormalization Group

By N. GOLDENFELD

1993, £23.95 (pbk), pp. xx + 394. Addison-Wesley, ISBN 0 201 55409 7. Scope: textbook. Level: postgraduate.

The phenomena associated with phase transitions, such as those which occur when a liquid is transformed into vapour or a ferromagnet loses its magnetization on heating, have long fascinated theoretical physicists. Particularly intriguing are critical states of matter, exemplified by the state of a fluid at its critical temperature and pressure, where the liquid and vapour states become indistinguishable. As a result of strong correlations between thermal fluctuations at widely separated points within a sample, many properties of systems in a critical state are universal, in the sense that they are essentially independent of the microscopic constitution of a particular substance.

More than 20 years ago, Kenneth Wilson (winner of the 1982 Nobel prize for physics) pioneered a mathematical technique, known as the renormalization group, by means of which the universal properties of critical points could be understood in detail. Over the years, renormalization-group methods have found applications to an extraordinarily diverse range of physical problems and a great many books have been written on the subject, several of which I have reviewed in these pages.

My initial dismay at receiving a review copy of yet another book on phase transitions and the renormalization group gave way rather quickly to interest and pleasure as I worked my way through Goldenfeld's account. Much of what he has to say has indeed been said before, but rarely in such a clear and accessible manner. In his preface, Goldenfeld stresses that his lectures cover *elementary* aspects of the physics of phase transitions. This is true, in the sense that much of the intricate mathematical machinery which has been deployed to obtain rigorous or exact results is avoided. On the other hand, the profound questions which prompted the development of this machinery are thoroughly examined. For example, it is easy to 'prove' that a ferromagnet cannot have a spontaneous magnetization. Everyday experience assures us that this proof cannot be correct, but a full understanding of the truth requires a sophisticated analysis, involving the ideas of *spontaneous symmetry breaking* (which is unavoidably discussed in any presentation of the subject) and *ergodicity breaking* (which is equally important, but rarely emphasized in textbooks at this level). Such matters are not at all elementary. It is a mark of Goldenfeld's powers of exposition that he provides enough digestible detail to make the nature of the truth apparent, while leaving his reader satisfied that the more forbidding mathematical subtleties can safely be postponed for later study. Many of the essential ideas are explained through explicit worked examples, giving the student a sense of security which is not easily gained from a more formal and general treatment.

The choice of topics to be covered in a book of this kind depends largely on the author's particular interests.

Goldenfeld describes the standard examples of phase transitions in fluids and magnets, but also discusses applications of the renormalization group to systems far from thermal equilibrium, basing his discussion on nonlinear diffusion equations. This interesting material has not, as far as I know, found its way into other comparable textbooks. My one disappointment is that the relationship between statistical mechanics and quantum field theory (the mathematical foundation of elementary particle physics) which becomes especially striking and fruitful in the context of phase transitions, is mentioned only briefly. But then, one cannot have everything. The interest which professional physicists have found in the theory of phase transitions seems to be inexhaustible. Graduate students seeking an introduction to this theory (and lecturers in search of a primary text) will not easily find a more readable, thorough and thought-provoking account than is offered here. More experienced physicists with some knowledge of the field will, perhaps, find little in the book that is essentially new to them, but those who enjoy a fresh visit to familiar territory will find Goldenfeld an interesting and stimulating companion.

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Lectures on the Free Electron Laser Theory and Related Topics

By G. Dattoli, A. Renieri and A. Torre

1993, £27.00 (pbk), pp. xxi + 637. World Scientific, ISBN 981 02 0566 X. Scope: lectures. Level: postgraduate.

'Why another book on Free Electron Lasers?' In response to their question posed in the book's preface, the authors argue for such a need if the book satisfies some of the following objectives:

(1) it should be a synthesis of disparate approaches to the study of free electron lasers (FELs);
(2) it should serve as an introduction to the field for graduate students; and
(3) it should serve as a useful reference manual for experienced scientists.

This is a rather ambitious programme to condense into one book, and in my opinion has not been entirely successful.

In keeping with the first objective, the first four chapters are devoted to discussions on electron beam optics, synchrotron radiation, synchrotron emission in undulated magnets, and to accelerators with radiative damping, respectively. These are technical topics not normally found in discussions on FELs, are competently written, and should serve as useful indicators to source material for the more experienced scientist. Introductory comments on FELs then follow in chapter five, intended to give an explanation of the basic mechanism to the novice. I found these comments rather unclear; it is not clear how axial bunching is produced, nor what is its central significance to these devices. However, discussions later in this same chapter on related topics such as stimulated Cerenkov radiation, Smith-Purcell and Gyrotron lasers, and channel radiation are interesting and serve as a useful contrast to the FEL material. The next three chapters are concerned with the derivation and discussion of the basic equations describing the physics of FEL devices. The pendulum equation—central to the FEL, which describes how electrons evolve under the joint action of the wiggler and radiation fields—is first derived, after which the manner in which the perturbed electrons self-consistently generate the radiation field is discussed. The treatment here is fairly standard, but there are clearer accounts elsewhere. Discussion of these equations is then linked to the linear evolution of the generated radiation field.

I would have liked to see more discussion of the mechanism responsible for the transition from incoherent to coherent generation of the radiation field, particularly so since comparisons are frequently made between the FEL and other devices. For example, channel radiation is incoherent; the ability to bunch the electrons and so evolve from the incoherent to coherent phase is what makes FELs useful devices. It might also have been useful to include a longer discussion on saturation effects, and on the accompanying sideband instability, since these are fairly active topics of research at present.

The book is fairly comprehensive and to some extent the authors have accomplished the first and last of their aims. However, graduate students or other newcomers to the field will find this a difficult book as a 'first read', though may benefit from its wide scope on acquiring some familiarity with the subject.

As a final comment, I note that both the editors and publishers have done the authors a considerable disservice. English is not the authors' first language and any reasonable attempt at editing would have removed many of the clumsier phrases. Similarly, some of the reproduction work is very poor; for example, wording in Figures 1.7 and 1.8 is illegible.

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