

## BOOK REVIEWS

**Introduction to Accelerator Physics.**  
Arvind Jain. Macmillan India Ltd. 2007.

Accelerators, primarily developed for research in nuclear and particle physics, are widely used for a range of science and technology programmes. Both ion and electron accelerators find wide usage in many areas of great relevance to society at large. The accelerator is a versatile tool in the field of medicine, both for diagnosis (through radio-isotopes produced using accelerators) and for therapy (e.g. cancer therapy, Boron neutron capture therapy). The industrial use of accelerators has grown tremendously over the years. Accelerator-based ultra sensitive mass spectrometry is another area where the power of the accelerator has been exploited. Material modification (mostly the surface) and characterization employing accelerators is another field of great interest to R&D personnel. Further, accelerators are increasingly being used for chemical and bioscience research. More recently, an accelerator-driven system has been proposed which involves coupling a high intensity, high energy accelerator to a sub-critical reactor core, so that the three objectives – power generation, fissile material breeding and nuclear waste transmutation – can be effectively met through this system. In India, the accelerator-based research and related activity has taken-off and it is timely that a book devoted to accelerator physics, by Arvind Jain has been published. This is perhaps the first book on this emerging topic written by an Indian author. As the author himself has observed, the present book though written for beginners in the field of accelerator physics, is equally appealing to the experts.

In the first five chapters of this book, Jain has introduced the various types of accelerators, DC and AC types, the linear and the cyclic varieties used for acceleration of electrons and ions. In addition to the various references provided, we can add one of the earliest treatises by Livingston on this topic. Discussion on the tandem van de Graaff is somewhat incomplete without reference to the excellent modern developments attributed to R. G. Herb, father of the modern pelletron accelerators.

Knowledge of the motion of charged particles in electric and magnetic fields is the most fundamental aspect of accelerator physics. Jain has devoted the next few chapters (6 to 13) to acceleration and

transportation of charged particles. Starting with the basic equations of motion, he has highlighted the role of betatron oscillations (horizontal and vertical types) and related resonances relevant to cyclic accelerators. He has pointed out as to why the resonances between the orbital and horizontal/vertical frequencies should be avoided. Then he proceeds to discuss the important focusing element in any accelerator, viz. the quadrupole lens. Phase space conservation and Liouville's theorem are important aspects of charged particle acceleration and beam transport. Various details related to charged particle transport in accelerator subsystems (including dipole magnets) and the importance of 'beam emittance, focus, waist and twiss parameters' are lucidly presented.

In chapters 14 and 15, Jain has provided elaborate details about synchrotron oscillations and synchrotron radiation sources. He has dealt with the concepts of phase, phase stability and synchronization in cyclic particle accelerators. The radiation emitted by high-energy electrons in a synchrotron (storage) ring constitutes the synchrotron radiation (the radiation increases as the fourth power of energy). This device has superior properties in terms of high intensity for various wavelengths (the critical wavelength is inversely related to the third power of energy) and brightness (million times higher than conventional X-ray tubes). Jain has also shown how using the wiggler it is possible to shift the critical wavelength to smaller values and how employing the undulator it is possible to obtain a spike in intensity at a particular wavelength. The first-generation synchrotron sources were operated in parasitic mode with the main usage of the accelerator being research in high energy physics. The second-generation sources were developed as dedicated light sources. The third-generation sources use a number of add-ons like wigglers and undulators to enhance the performance of the synchrotron source. It is clear from the discussions that high vacuum better than  $10^{-9}$  torr is crucial in the ring to enhance the stored beam lifetime.

In chapter 16, Jain has discussed another topic of importance, viz. chromaticity (chromatic aberration) and how it can be controlled. In chapter 17, he has dealt with 'instabilities' in general, both in linear and cyclic accelerators. This will be useful for experts in the field. He

has discussed in detail the electric field associated with a charged particle moving with a velocity close to that of light, the multipoles generated due to hollow ring beam propagating through the beam pipe and the wake field generation due to beam bunch with multipole moments moving down a resistive walled pipe and the various instabilities in linacs/cyclic accelerators. Comprehensive accounts of linear accelerators and sector-focused cyclotrons are provided in chapters 18 and 19. The resonators, skin depth, transit time factor, shunt impedance, focusing aspects, operating frequency, different kinds of LINACs, including the radio-frequency quadrupole, and RF power are some of the features discussed in the case of LINAC, which should be exciting to both the beginners and the experts. Having worked for a good part of his professional career on sector-focused cyclotron (being one of the leading persons involved in the indigenous development of the first AVF cyclotron in the country), Jain has handled the topic of sector-focused cyclotrons in a masterly way starting from basics to the advanced versions of cyclotrons, like separated sector cyclotrons. Chapter 20 is devoted to the role of superconductivity in frontier areas of accelerator technologies. Developments in superconducting magnets (enables going to higher magnetic fields) and superconducting radio frequency cavities (with considerably low power requirement and losses) of different types are the technologies driving the modern-day accelerators. Jain has covered these developments based on superconductivity in a professional manner in this concluding chapter. He has made a successful attempt to bring the reader up-to-date with the accelerator developments starting from the basics and the early days.

The book is written not only by an accelerator professional, but also by one who has taught the course on accelerator physics successfully in the BARC graduate school at Mumbai for many years. One would have liked at least a chapter of this book devoted to accelerators for frontiers in science and technology. Interested readers may refer to the recent publication of the Indian Association of Nuclear Chemists and Allied Scientists (2006) on this topic. Needless to say, the material contained here is well tested in classrooms and hence can serve as a good textbook for a course on the subject. One nice feature of the book has been the

worked-out examples based on the many formulae appearing in the various chapters. These exercises provide the reader with a working knowledge of their use and a feeling for numbers, magnitudes and dimensions involved.

S. KAILAS

Nuclear Physics Division,  
Bhabha Atomic Research Centre,  
Mumbai 400 085, India  
e-mail: drskailas@rediffmail.com



**Chlorophylls and Bacteriochlorophylls: Biochemistry, Biophysics, Functions and Applications.** B. Grimm *et al.* (eds). Springer. 2006. 603 pp.

Research on the chemistry of chlorophylls (Chls) and bacteriochlorophylls (BChls), the most abundant pigments of plants, algae, cyanobacteria and photosynthetic bacteria, has attracted the attention of the Nobel Committee and has led to three Nobel prizes in chemistry to: Richard Wilstätter (1915), Hans Fischer (1930) and Robert Burns Woodward (1965). In the energy-demanding world, that now shows a lot of interest in alternate sources of energy, other than the fossil fuel, this edited book on Chls that absorb and utilize solar energy is most timely. The practical applications of solar energy absorption and its conversion to food and fuel by Chls and BChls; its importance in climate change especially in global warming in high CO<sub>2</sub> regimes, and the medical applications of Chls and BChls, especially in photodynamic therapy of cancer, will continue to be an intensive research field in the present century. Many of these applications are included in this volume. The book will give im-

petus to further research in several other emerging areas of photosynthesis, which are of both ecological and biomedical nature.

This book is a part (vol. 25) of the *Advances in Photosynthesis and Respiration Series* (Series Editor, Govindjee). It has 37 chapters dealing with Chls and BChls, written by 70 established authors in the field. In 1991 Hugo Scheer had edited a book *Chlorophylls*, that was published by CRC Press, Boca Raton, Florida. The current book is also an edited volume, but covers a much greater depth than the earlier book. It contains several colour plates and reviews recent progress in the current status of knowledge of metabolism, spectroscopy, chemistry of Chl and BChl and their assembly in pigment-protein complexes.

An introductory overview of occurrence, absorption and emission maxima, structure and function of different forms of Chls and BChls, is included in a thorough chapter (Scheer) that will serve as a quick reference for graduate students and scientists working on tetrapyrroles. The next five chapters elucidate in detail the conformational flexibility, chemical synthesis, and chemical modifications of chlorophylls (Senge *et al.*); chemistry, absorption spectra, separation and distribution of chlorophyll *c* (Zapata *et al.*); unusual tetrapyrrole pigments of photosynthetic antennae and reaction centres in photosynthetic bacteria and plants (Kobayashi *et al.*); heavy metal-chlorophylls (Küpper *et al.*), and absorption and fluorescence properties, mass spectra and NMR spectra of several forms of Chl and BChl (Kobayashi *et al.*). These chapters describing the synthesis, detailed chemistry and spectroscopic properties of several unusual Chls, will immensely help researchers working in the field. The book also provides exhaustive information on spectrophotometric and spectrofluorometric estimation of Chls and BChls (Porra); separation of different chlorophylls and carotenoids using High Performance Light Chromatography (Garrido and Zapta), and others by simple open-column chromatographic methods (Shioi). These chapters will be helpful to researchers working on purification of plant pigments. Chl biosynthesis is nicely presented (Rüdiger and Grimm); up-to-date information on 5-aminolevulinic acid biosynthesis and structural details of enzymes involved in its synthesis are also available (Beale, Jahn *et al.*), as

well as biosynthesis of protochlorophyllide and protoheme (Yaronskaya and Grimm) and finally the formation Chl *a*, Chl *b* and BChl (Rüdiger, Friggard *et al.*). The involvement of tetrapyrroles in cellular regulation, especially their role in inter-organellar signalling, is covered in the book (Beck and Grimm), as well as Chl catabolism that deals mostly with the biochemistry of Chl degradation products (Kräutler and Hörtensteiner). A chapter on the evolution of Chl, BChl and oxygenic photosynthesis (Larkum) is thought-provoking and will be of great interest to all biologists.

Several chapters in the book on the topic of the 'Native environment', and the various techniques to understand it, follow: Physical properties of protein-BChl interaction (Allen and Williams); magic angle spinning NMR of the chlorosomes (de Boer and deGroot); single molecule spectroscopy of pigment-protein complexes from purple bacteria (Köhler and Aartsma); Raman spectroscopy of bacteriochlorins (Koyama *et al.*), and mapping of global ring currents of porphyrins and chlorins (Steiner and Fowler) are other rare chapters, nicely elucidated along with appropriate figures.

Chls and BChls are always complexed with proteins in living organisms. The book rightly addresses the problem of assembly of Chl-protein and BChl-protein complexes and supramolecular organization of these complexes in plants and bacteria (Noy *et al.*, Nango, Paulsen, and Garcia-Martin *et al.*). Four chapters cover the functions of Chls and BChls. The excitation energy transfer within Chls (Leupold *et al.*); carotenoids to Chls (Koyama and Kakitani); electron transfer in the photosynthetic reaction centre (Wachtveitl and Zinth); utilization of the solar energy by Chl and protective functions of Chl (Melkozernov and Blankenship); utilization of Chl *a* fluorescence as a signature of photosynthesis (Nedbal and Koblížek); monitoring Chl in the ocean from outer space by remote sensing (Morel) and geochemistry of Chl (Keely) are nicely described and critically discussed in the book.

A significant aspect of the book is the discussion of the use of Chl, BChl and their biosynthetic intermediates to therapeutic research, especially in photodynamic therapy of cancer. Two chapters (Brandis *et al.*) will be useful to researchers working in the area of photomedicine.