Preface

Since the first observation of synchrotron radiation in 1947, progress in the generation of electromagnetic radiation using particle accelerators and in experimental methods has allowed enormous progress in the fine analysis of matter. This progress has not been incremental but rather truly innovative and in some cases revolutionary. Thanks to advances in accelerator physics and technology the improvement in the characteristics of synchrotron radiation and free electron laser sources, especially brilliance, coherence and time structure, has spanned many orders of magnitude. At the same time, new methods to investigate matter have been developed which have led to original approaches for its characterization in the domains of real and reciprocal space, energy and time. Progress in these two aspects—sources and experimental methods—has been truly synergic.

While the first applications of synchrotron radiation were in the field of solid-state physics, its use now is ubiquitous in all the physical and natural sciences, with also significant medical applications. 'Samples' studied at beamlines range from man-made inorganic materials and devices, natural minerals and rocks, environmentally significant specimens, cultural heritage materials, biologically relevant molecules, tissues and in some cases even live human patients.

The importance and societal relevance of synchrotron radiation has been recognized by the scientific community and by policy makers worldwide. Due to the investment and operation costs required to operate a synchrotron radiation or free electron laser source, centralized large-scale infrastructure user facilities have been developed. In recent decades, there has been an evolution from the parasitic use of synchrotron radiation emitted by accelerators designed for particle physics experiments to facilities specially designed exclusively for photon science-based experiments. The scientific goal of numerous important national laboratories in the world has changed from particle physics to photon science.

Most industrialized and some developing countries now have a national synchrotron radiation facility; there are also important examples of international cooperation for the construction and operation of facilities, ranging from the European Synchrotron Radiation Facility in Grenoble, a major laboratory funded by a wide European collaboration, to SESAME—a UNESCO sponsored project intended also as a means to encourage collaboration and peace in the Middle East. Access to these facilities is commonly regulated by an open access policy based exclusively on merit: whoever has a good idea to use synchrotron radiation has free access to the instruments; this is a key aspect which contributes very significantly to maintain a competitive, curiosity-driven and young intellectual community all over the world. In parallel, synchrotron radiation and free electron laser sources are a key tool to meet important societal challenges in the near future, including providing essential tools to characterize nanostructures and advanced materials used in key areas of future technologies in the inorganic and bio areas; refined methods to characterized new materials and devices are essential to provide key answers in challenging areas such as, for example, those defined by the Horizon 2020 programme of the European Union, including health and wellbeing, sustainable agriculture, secure, clean and safe and efficient energy and a clean environment.

This is the context within which we are proud to present this book, which reports the lecture notes of lessons held at the 12th edition of the School on Synchrotron Radiation, organized by the Italian Synchrotron Radiation Society (Società Italiana di Luce di Sincrotrone, SILS, www.synchrotron-radiation.it) in collaboration with Elettra—Sincrotrone Trieste (www.elettra.eu). SILS is one of the oldest independent scientific societies, the objective of which is to promote synchrotron radiation in Italy in the European context.

The School took place in the town of Grado (near Trieste) in September 2013 and benefited from partial financial support from COST Action MP1103—Nanostructured materials for solid-state hydrogen storage. The directors of the school were Settimio Mobilio and Gilberto Vlaic. The SILS school has become one of the most important educational events in the field of synchrotron radiation in Europe. Its important role is testified by the high number of applications (over 100 for 45 places) and the strongly international character, with participants coming from as far away as Canada, China and Iran. In the course of the two weeks' duration, which included a full day devoted to a practical session at Elettra, including hands on experience at selected beamlines and data analysis, the lectures covered the fundamentals of synchrotron radiation and free electron laser emission, the interaction between electromagnetic radiation and matter, the main experimental methods and the most important and recent applications.

All these aspects are included in this volume, which is organized as follows. Part I describes the emission of synchrotron and free electron laser sources and the basic aspects of beamline instrumentation; Part II illustrates the fundamentals of the interaction between electromagnetic radiation and matter; Part III describes the most important experimental methods, ranging from spectroscopies, diffraction and scattering, to imaging; finally, Part IV reports a range of applications of current topical interest.

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http://www.springer.com/978-3-642-55314-1

Synchrotron Radiation
Basics, Methods and Applications
Mobilio, S.; Boscherini, F.; Meneghini, C. (Eds.)
2015, XXIV, 799 p. 389 illus., 150 illus. in color.,
Hardcover
ISBN: 978-3-642-55314-1