Preface

In a first approximation, certainly rough, one can define as non-crystalline materials those which are neither single-crystals nor poly-crystals. Within this category, we can include disordered solids, soft condensed matter, and live systems among others. Contrary to crystals, non-crystalline materials have in common that their intrinsic structures cannot be exclusively described by a discrete and periodical function but by a continuous function with short range of order. Structurally these systems have in common the relevance of length scales between those defined by the atomic and the macroscopic scale. In a simple fluid, for example, mobile molecules may freely exchange their positions, so that their new positions are permutations of their old ones. By contrast, in a complex fluid large groups of molecules may be interconnected so that the permutation freedom within the group is lost, while the permutation between the groups is possible. In this case, the dominant characteristic length, which may define the properties of the system, is not the molecular size but that of the groups. A central aspect of some non-crystalline materials is that they may self-organize. This is of particular importance for Soft-matter materials. Self-organization is characterized by the spontaneous creation of regular structures at different length scales which may exhibit a certain hierarchy that controls the properties of the system.

X-ray scattering and diffraction have been for more than a hundred years an essential technique to characterize the structure of materials. Quite often scattering and diffraction phenomena exhibited by non-crystalline materials have been referred to as non-crystalline diffraction. Non-crystalline materials may exhibit weak X-ray scattering power mainly due either to a low level of order or to little electronic density contrast. Again, the last effect is especially important for soft-matter materials which frequently are composed of light atoms and a great amount of water. For instance, it is known that typical dilute protein solution scatters 1 photon every 10^5 incident photons. This example immediately illustrate the necessity of powerful X-ray sources offering high photon fluxes. The initial use of first-generation synchrotron light in the 1960s of the 20th century for diffraction experiments opened up tremendous expectations for the scientific community involved in non-crystalline materials. Many of these expectations have been fulfilled along the time as demonstrated by the increasing amount of third-generation synchrotron facilities available in the actuality and by those which are under construction all around the world. This fact makes that synchrotron light is becoming most and most popular even among non-synchrotron radiation specialists. Obviously this is a desirable "side-effect" considering the tremendous amount of investment done at both national and trans-national level in these facilities. Accordingly, it is expected an increasing amount of synchrotron users aiming to use scattering and diffraction techniques to elucidate a broad variety of systems and problems.

The present volume of Lecture Notes in Physics, entitled **Applications of Synchrotron Light to Scattering and Diffraction in Materials and Life Sciences**, originates from the necessity to bridge the gap between beam-line manuals and highly specialized text books. The collection of contributions presented in this book attempts to cover most of the aspects in which the combination of synchrotron light with scattering and diffraction techniques can be very helpful in order to provide essential information on the structure of large molecular assemblies in low-ordered environments. Contributors have been selected based on their engagement as advanced synchrotron users aiming to present contributions as close as possible to the beam-line work. Special emphasis was done on including contributors who are involved on the management and day-by-day activity of representative beam-lines devoted to Non-crystalline Diffraction as they are ID2, ID13, and BM26 at the European Synchrotron Radiation Facility(ESRF) (France), X27C at the National Synchrotron Light Source(NSLS) (USA) and NCD (port-11) at ALBA (Spain). The book has been divided into two main sections comprising fundaments and applications. The first section contains a first chapter dedicated to introduce the reader to the bases of synchrotron radiation, light sources and beam-lines and a second one presenting the fundaments of scattering by soft-matter. Considering the increasing application of scattering and diffraction to nanomaterials, third and fourth chapters focus on the use of grazing incidence and microfocus in X-ray scattering, respectively. The application section has been divided into two parts dealing with materials science (Part II) and life sciences (Part III). In part II an attempt has been made to include examples of applications on non-crystalline diffraction in broad selection of representative non-crystalline materials including hard and soft colloids (Chaps. 5 and 6), liquid-crystalline polymers (Chap. 7), nanocomposites (Chap. 8) and carbon fibres (Chap. 9). Additionally chapters 5 and 10 emphasize potential advantage of combining non-crystalline diffraction with other techniques like EXAFS, dielectric spectroscopy or calorimetry. In part III, two main chapters deal with the application of X-ray scattering to elucidate protein shapes in solution by using either conventional X-rays (Chap. 11) or synchrotron light (Chap. 12). These two chapters emphasize how conventional X-rays and synchrotron radiation are far from being antagonists. Finally, Chaps. 13 and 14 present the potential use of X-ray scattering to medical diagnosis and to elucidate the biophysics of natural muscle dynamics.

We hope that this issue of Lecture Notes in Physics may contribute to a more general understanding about the combination of synchrotron light with scattering and diffraction techniques in non-crystalline materials. Moreover, we expect that, by presenting a snap-shot of the state of the art in this field, the community of synchrotron users interested in these topics may eventually be enlarged.

Madrid,
February 2008

Tiberio A. Ezquerra
MariCruz García-Gutiérrez
Aurora Nogales
Marían Gómez

http://www.springer.com/978-3-540-95967-0

Applications of Synchrotron Light to Scattering and Diffraction in Materials and Life Sciences

Ezquerra, T.A.; Garcia-Gutierrez, M.C.; Nogales, A.; Gomez, M. (Eds.)

2009, XVI, 318 p. 177 illus., 20 illus. in color., Hardcover
ISBN: 978-3-540-95967-0