INTRODUCTION

This chapter presents selected activities that are related to Atomic and Condensed Matter Physics. In the broad field associated to these two domains we only focus on questions whose study requires the use of nuclear techniques and facilities. In some cases the research related to these questions now develops around specific and independent installations, but most of the results presented in the chapter have been obtained in a Nuclear Physics environment. We have deliberately decided not to present the very broad and productive research achieved with the light sources associated to synchrotron radiation. These facilities are obviously among the most used in Physics, Chemistry and Biology. However, they constitute a whole world that lives its own life independently of Nuclear Physics.

The work presented here often deals with very basic problems: concepts, models and techniques in Nuclear Physics can be applied to the development of fundamental research in other areas. The reverse is also obviously true: the borders between disciplines are porous and cross-fertilisation greatly contributes to the development of Physics. This is certainly the case in the interplay between Nuclear, High Energy and Atomic Physics that is analysed in section1 and section 2. There, it is shown for instance how spectacular technical breakthroughs have led to orders of magnitude improvements in precision when testing quantum electrodynamics in very strong fields. Much effort goes into the search for physics beyond the standard model: let us mention, for instance, studies of weak interactions through the determination of the full kinematics of nuclear β decay in atomic traps. Such traps are also used in mass spectroscopy measurements providing high precision mass determination of stable and radioactive nuclides. This shows how instruments and experimental techniques first developed for atomic physics purposes provide important information on nuclear properties. In this domain, measurements concern determination of half-live, spins, magnetic and electric moments and charge radii of nuclides. One can also benefit from a solid state physics technique (ion blocking) to study long lifetime components of excited nuclei or of exotic heavy nuclei, in relation with nuclear dissipation.

The successive sections of the chapters are transitively linked. Section 3 is also devoted to atomic physics and specifically describes the impressive progress made in the study of atomic collisions. There is first a definite improvement in precision that now allows tracking of all the collision products and thus provides access to the details of collision dynamics. but there is also an extension of the observations and modelling in more and more complex systems: modification of the target electron density around an ion moving in solids and associated oscillation of its excited state population, cluster ion stability and dissociation, interaction of very slow highly charged ions with surfaces….

Section 4 deals with the modification of materials induced by irradiation and associated applications. The connection with the preceding section is clear: the primary events that lead to the observed modifications are the atomic collisions. However, the response of the medium to these primary events involves a higher level of complexity; on this question important progress has been made. This is of prime importance insofar as biological matter and life sciences (particularly therapy) are concerned, and the work presented in section 4 is thus of particular interest for many features of chapter 1. The connection with chapter 3, devoted to Energy, is also obvious: one has to predict the evolution under irradiation of nuclear fuel and of matrices for nuclear waste transmutation.

Section 5 presents major developments recently achieved in the most important techniques of material analysis related to Nuclear Physics. These developments are connected to the improvement of sources, beams and detectors. They result in spectacular gains in sensitivity as well as in spatial and time resolution for the analysis of the composition, structure, dynamical evolution and physical properties (for instance magnetism) of all kinds of materials. Among these techniques, those based on the use of ion beams require a precise knowledge of the ion-solid interactions and associated effects that are presented in sections 3 and 4.

The technical developments that provide the base for the work presented in the first five sections of this chapter, as well as the technical perspectives for the near future are detailed in section 6. It clearly appears that many improvements around Nuclear Physics facilities are beneficial for various other fields. in the future, it would thus certainly be important to include the possible use of such facilities as "multidisciplinary tools" in the planning stage, requesting input from members of diverse scientific communities. Of course, the access to these tools should then also be more widely open.