General Summary

Astronomy has been one of the fastest growing sciences in the recent decades, a field where a succession of major discoveries was followed by all audiences with passionate interest. The purpose of this book is to present the major achievements in astronomy in the last century in a succinct way, review the most recent advancements, and provide a sketch of the future. We hope that the reader, when introduced to the richness of the Universe, will appreciate how the recent discoveries have deeply changed our vision of the world.

Astronomy has much more evolved in the last century than in the previous two centuries when it simply continued to progress among the other sciences, after having spearheaded the first scientific revolution in the 16th and 17th centuries with Copernicus, Galileo and Newton. Today, it seems surprising that, only a century ago, the vision of our ancestors was so short-sighted. In contrast, our Universe is incomparably richer after the continuous series of fundamental discoveries made in the 20th century. In a hundred years, the known Universe has gained an enormous factor in both its dimensions and history spanning 14 billion years since its origin. We have discovered that the observable universe is made of hundreds of billion galaxies, surrounded by vast empty spaces, each containing an exuberant variety of stars, exoplanets, black holes and many other objects with extreme physical conditions. Yet, we remain amazed by its surprising unity. As far as we look with our telescopes, reaching towards the edge of the Universe, we find in each galaxy exactly the same physics, the same atoms, practically the same classes of stars and galaxies comparable to our Milky Way and its neighbors at various stages of evolution. Today, most of the questions about the nature and the physics of the various stars and their history have been answered. However, despite these remarkable advances, our Universe is still rich with fundamental unsolved questions regarding its physics, its basic constituents and their nature, including the origin of life.

This recent progress in our exploration of the Universe is directly linked to the accelerated path of knowledge in physics and the fast-evolving technical

development throughout the 20th century. Understanding the Universe and its constituents would not have been possible without the revolutions of quantum and relativistic physics. Astronomy has also fully benefited from the technological revolutionary progress in multiple domains, resulting in increasing sizes and performances of telescopes together with improved sensitivities and greater pixel numbers of the detectors. It is now possible to explore the Universe at wavelengths other than the visible (radio, millimeter, infrared, ultra-violet, X-rays and gamma-rays), as well as through non electromagnetic signals (cosmic rays, neutrinos, gravitational waves), enabling, by their combination, to trace the full complexity of celestial sources. Observing from space allows us to get free from atmospheric blockages and disturbances. The exponential growth in information technology opens up almost unlimited possibilities for data processing and analysis.

Without aiming to be exhaustive, this book proposes an overview of the main advances in astronomy in the 20th century, highlighting the major breakthroughs in our discovery of the Universe and providing sufficient details to capture the overall progress of this science. It is divided into five main themes: stars, galaxies, cosmology, high energy astrophysics and planets. For each of them, the most revolutionary progress made in the last century will be highlighted.

The observational knowledge of stars was already remarkably advanced in 1900. The 20th century revolution in this field consists in the deep understanding of the physics underlying stellar evolution. This provided the answer to two crucial questions: (i) their source of energy; (ii) the origin of the chemical elements of which we are made. On the other hand, it seems difficult to imagine that the concept of galaxies had not yet been accepted only a century ago, while the role of galaxies, including ours, is now part of our cultural background. The study of galaxies has since become one of the major areas of research in astronomy. Modern cosmology was actually born with the discovery of the recession motion of nearby galaxies and the expansion of the Universe that it implies. It has gradually flourished for almost a hundred years in the context of general relativity and particle physics. Cosmology, *i.e.* understanding the global properties of the Universe, is today one of the keystones of astrophysics, raising some of the fundamental questions of physics. Likewise, the most violent activity taking place in the Universe remained practically unsuspected a hundred years ago. Its gradual exploration has revealed a whole series of extraordinary objects, including supernovae, quasars and black holes, bringing enormous energies and extreme physics into play. Finally, the last third of the 20th century saw the fulfillment of two recurring dreams of humanity: first the beginning of direct exploration of the Solar System, then the discovery of planets around stars other than the Sun. Today, there are rich future prospects for the search for extraterrestrial life, and the study of exoplanets has become one of the most promising astronomical projects.

Since there is no need for complicated mathematics to understand the deep reality of the astronomical world, mathematical formulas and complex notions of physics have been mostly avoided in this book. However, to provide precise benchmarks on astrophysical objects and phenomena, one cannot completely ignore a few basic notions such as the powers of ten, the constituents of the atom or

the scales of temperature and energy. A brief glossary aims to provide guidelines and, for curious readers, the key to explore more complex concepts.

This book is intended for readers of any level albeit full of curiosity. It aims to give everyone the opportunity to wonder at the exuberant richness of the Cosmos, penetrating right into the fabulous world of astronomers. The aim is to give keys so as to understand some of the main questions that astronomy raises. To use Newton's beautiful image, we are still on the shore of the Universe, facing the immensity of its mysteries. We begin to superficially penetrate its many secrets, playing with its unusual wonders, while still remaining at the edge of the unknown.