Preface

There is a common perception among the general populace that astronomy is impractical and irrelevant. This could not be further from the truth. For thousands of years, astronomy was an extremely practical subject, and our ancestors relied on their astronomical knowledge to conduct their daily lives. Most ancient people were far more familiar with the behavior of the Sun, the Moon, and the stars than the average person is today. Astronomy also motivated intellectual thought and had a major impact on the social development of the human race throughout history. Our evolving perception of our place in the universe helped bring about important social changes over the last two thousand years.

This book is not just about astronomy. It uses the historical development of astronomy to illustrate the process of rational reasoning and its effect on philosophy, religion, and society. Because celestial objects followed regular patterns, astronomical observations gave humans some of the first hints that Nature was understandable. The complicated nature of these patterns also challenged our intellectual powers.

In our education system, science is often presented to our students as a series of facts. In fact, science is about the process of rational thinking and creativity. What we consider to be the truth is constantly evolving and has certainly changed greatly over the history of humankind. The essence of science is not so much about the current view of our world but how we changed from one set of views to another. This book is not about the outcome but the process.

I tried to achieve these goals as follows. I begin with a description of basic observations, summarize the patterns observed and the problems they pose, and discuss the suggested theories and their implications. The pros and cons of these theories are evaluated alongside alternate theories. This approach differs from typical science textbooks, which usually take an axiomatic approach by first stating the correct theory and deriving the deductions before comparing them with experimental results. I hope this historical approach allows students to better understand the scientific process and learn from this process when they tackle real-life problems in their careers.

We live in the most prosperous times in human history. It is convenient to assume that everything important happened recently and that events from the distant past do not matter. It is also easy for us to forget or dismiss the wisdom and achievements of our ancestors. A simple survey of modern university students will reveal that most of them believe we discovered the Earth was round only a few hundred years ago. But in fact the Earth's shape was well known as long as 2500 years ago.

With naked eye observations and some very simple instruments, ancient astronomers found out a great deal about our world. By observing celestial objects, they deduced that the Earth was round. They could explain the changing times and locations of sunrise. They had a reasonable empirical model to forecast eclipses. In spite of the apparent erratic motions of the planets, their positions could be predicted accurately with mathematical models hundreds of years into the future. Although ancient civilizations occupied only a small fraction of the surface of the Earth, they had a very good estimate of the size of the entire Earth. They could even determine the size of and distance to the Moon.

Modern humans' disconnection from Nature also means that some common knowledge from ancient times has been lost. Many people today believe that the Sun rises in the east every day, but it was common knowledge among our ancestors that the direction of sunrise changes every day. The regular yet complex apparent motion of the Sun was the main motivator for the development of rational thought.

This book is based on a course designed for the Common Core Program of The University of Hong Kong (HKU). The HKU Common Core courses are not based on a specific discipline and are designed to help students develop broader perspectives and abilities to critically assess complex issues. The classes also help students appreciate our own culture and global issues.

I developed this course and taught it from 2010 to 2016. Every year, the class contained about 120 students from all faculties of the University, including Architecture, Arts, Business and Economics, Dentistry, Education, Engineering, Law, Medicine, Science, and Social Sciences. Because of the students' diverse background, no mathematical derivations or calculations were used. The students were, however, expected to understand qualitative concepts, develop geometric visualizations, and perform logical deductions. In order to convey the concepts effectively without mathematics, I relied strongly on graphical illustrations and animations. Computer simulations were used to show apparent motions of celestial objects in the sky. These illustrations greatly helped students visualize the complexity of such motions.

For more technical readers, I have added some mathematics in this book, most of which is presented in the Appendices. Nonmathematical readers can skip these parts. To focus on the evolution of concepts, I have deliberately omitted certain details. For example, the apparent motions of the Sun and Moon are even more complicated than I have presented here. My goal is to reach a broad readership.

Jargons are great obstacles to learning. In this book, I try to minimize the use of jargons as much as possible and some technical terms are replaced by simple words with similar meaning. Some concepts have precise definitions, and the use of technical terms is unavoidable. All definitions are presented in the Glossary.

Every year, students ask me whether they will be handicapped by their lack of previous knowledge of physics and astronomy. In fact, the reverse is true. Students in science have been told all the modern notions but have never learned how we arrived at those conclusions. To learn about the process of discovery, they have to give up their preconceptions, which can be hard for some students. One example is the question "How do we know that the Earth revolves around the Sun?" When I posed this question to students, the most common answer I got was "This is what I was told by my teacher." In this book, we try to retrace historical steps to find out how we got to this conclusion.

In addition to lectures, we had weekly tutorials, quizzes, assignments, computer laboratory exercises, a planetarium show, and exams. The planetarium show was developed with the assistance of the Hong Kong Space Museum to illustrate the celestial motions observed in different parts of the world and at different times in history. The laboratory exercises were based on computer software so that students could have firsthand experience viewing and recording data from simulated observations. The assessments were designed to test whether the students had understood the course materials, could connect material from different parts of the course, had achieved some degree of synthesis, and could apply the acquired knowledge to new situations.

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I first became interested in this subject during my second year of undergraduate study at McMaster University, where Prof. Bertram Brockhouse (Nobel Prize in Physics, 1994) introduced me to Kepler's work in his Philosophy of Science course. His teaching made me realize that physics is more than just mechanical calculations; it is a subject with philosophical and social implications.

Vancouver, Canada Sun Kwok
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