Preface

Preface to the First Edition

This work is appearing in two parts because its mass is the result of combining detailed exposition and recent scholarship. Book I, dealing mainly with the inner solar system, and Book II, mainly on the outer solar system, represent the combined, annually updated, course notes of E. F. Milone and W. J. F. Wilson for the undergraduate course in solar system astrophysics that has been taught as part of the Astrophysics Program at the University of Calgary since the 1970s. The course, and so the book, assumes an initial course in astronomy and first-year courses in mathematics and physics. The relevant concepts of mathematics, geology, and chemistry that are required for the course are introduced within the text itself.

Solar System Astrophysics is intended for use by second- and third-year astrophysics majors, but other science students have also found the course notes rewarding. We therefore expect that students and instructors from other disciplines will also find the text a useful treatment. Finally, we think the work will be a suitable resource for amateurs with some background in science or mathematics. Most of the mathematical formulae presented in the text are derived in logical sequences. This makes for large numbers of equations, but it also makes for relatively clear derivations. The derivations are found mainly in Chaps. 2–6 in the first volume, *Background Science and the Inner Solar System,* and in Chaps. 10 and 11 in the second volume, *Planetary Atmospheres and the Outer Solar System.* Equations are found in the other chapters as well but these contain more expository material and recent scholarship than some of the earlier chapters. Thus, Chaps. 8 and 9, and 12–16 contain some useful derivations, but also much imagery and results of modern studies.

The first volume starts with a description of historical perceptions of the solar system and universe, in narrowing perspective over the centuries, reflecting the history (until the present century, when extra-solar planets again have begun to broaden our focus). The second chapter treats the basic concepts in the geometry of the circle and of the sphere, reviewing and extending material from introductory astronomy courses, such as spherical coordinate transformations. The third chapter then reviews basic mechanics and two-body systems, orbital description, and the computations of ephemerides, then progresses to the restricted three-body and *n*-body cases, and concludes with a discussion of perturbations. The fourth chapter treats the core of the solar system, the Sun, and is not a bad introduction to solar or stellar astrophysics; the place of the Sun in the galaxy and in the context of other stars is described, and radiative transport, optical depth, and limb-darkening are introduced. In Chap. 5, the structure and composition of the Earth are discussed, the Adams–Williamson equation is derived, and its use for determining the march of pressure and density with radius described. In Chap. 6, the thermal structure and energy transport through the Earth are treated, and in this chapter the basic ideas of thermodynamics are put to use. Extending the discussion of the Earth's interior, Chap. 7 describes the rocks and minerals in the Earth and their crystalline structure. Chapter 8 treats the Moon, its structures, and its origins, making use of the developments of the preceding chapters. In Chap. 9, the surfaces of the other terrestrial planets are described, beginning with Mercury. In each of the three sections of this chapter, a brief historical discussion is followed by descriptions of modern ground-based and space mission results, with some of the spectacular imagery of Venus and Mars. The chapter concludes with a description of the evidence for water and surface modification on Mars. This concludes the discussion of the inner solar system.

The second volume begins in Chap. 10 with an extensive treatment of the physics and chemistry of the atmosphere and ionosphere of the Earth and an introduction to meteorology, and this discussion is extended to the atmospheres of Venus and Mars. Chapter 11 treats the magnetospheres of these planets, after a brief exposition of electromagnetic theory. In Chap. 12, we begin to treat the outer solar system, beginning with the gas giants. The structure, composition, and particle environments around these planets are discussed, and this is continued in Chap. 13, where the natural satellites and rings of these objects are treated in detail, with abundant use made of the missions to the outer planets. In Chap. 14, we discuss comets, beginning with a historical introduction that highlights the importance of comet studies to the development of modern astronomy. It summarizes the ground- and space-based imagery and discoveries, but makes use of earlier derivations to discuss cometary orbits. This chapter ends with the demise of comets and the physics of meteors. Chapter 15 treats the study of meteorites and the remaining small bodies of the solar system, the asteroids *(aka* minor planets, planetoids), and the outer solar system "Kuiper Belt" objects, and the closely related objects known as centaurs, plutinos, cubewanos, and others, all of which are numbered as asteroids. The chapter ends with discussions of the origin of the solar system and of debris disks around other stars, which point to widespread evidence of the birth of other planetary systems. Finally, in Chap. 16, we discuss the methods and results of extra-solar planet searches, the distinctions among stars, brown dwarfs, and planets, and we explore the origins of planetary systems in this wider context.

At the end of nearly every chapter we have a series of challenges. Instructors may use these as homework assignments, each due 2 weeks after the material from that chapter were discussed in class; *we* did! The general reader may find them helpful as focusing aids.

Preface to the Second Edition

As in the first edition, we maintain the two-volume bifurcation of the inner and outer regions of the solar system. In the first volume, we again begin with a historical overview but expand the horizon to include glimpses of extra-solar planetary systems. The basic mathematics, mechanics, geophysics, thermodynamics, chemistry, astrophysics, and mineralogical principles required for a sound introduction to space science have been revised with improved illustrations and examples drawn from wider sources. In Chap. 4, we have added descriptions of the features of the active Sun. Chapter 8, on the Moon, has been updated with results of probes of water at the poles and a fresh discussion of the Moon's origin. In Chap. 9, the Messenger mission has provided vital new details about Mercury, and the history of the study of Venus has been expanded. The Mars section includes results from the Curiosity mission and a description of current views of the search for life in the Viking mission. The crustal changes in Mars since its formation, and an enlarged discussion of climate changes, expand that section further. Similar expansions of the chapters of the second volume have vastly expanded the discussions of atmospheres, magnetospheres, the gas and ice giants of the outer solar system and their moons and ring systems. The discussion of meteors and meteorite impacts has been enlivened by recent events, and a deepening understanding of the role played by disks in the early history of planetary formation. The burgeoning field of extrasolar planets has been reflected in the vastly increased discussion in the last chapter, with the increasing knowledge of the properties of extrasolar planets and their more massive siblings, the brown dwarfs. The dynamical interactions being studied with increasingly sophisticated software simulations have greatly illuminated the likely dynamical development of the solar system. As in all such investigations, present questions have been and are being answered, but new puzzles arise, and it is the anticipation of the new adventures required to explain them that makes this field truly exciting.

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