Preface

This book on recent investigations of the dynamics of celestial bodies in the solar and extra-Solar System is based on the elaborated lecture notes of a thematic school on the topic, held as a result of cooperation between the SYRTE Department of Paris Observatory and the section of astronomy of the Vienna University. Each chapter corresponds to a lecture of several hours given by its author(s). The book therefore represents a necessary and very precious document for teachers, students, and researchers in the field.

The first two chapters by A. Lemaître and H. Skokos deal with standard topics of celestial mechanics: the first one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, secular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun. The second one deals with approximative methods of describing chaos. These methods, some of them being classical, as the Lyapounov exponents, other ones being developed in the very recent past, are explained in full detail. The second one explains the basic principles of resonances in mechanics and their studies in the case of the Solar System. The differences between the various cases of resonance (mean motion, secular, etc.) are emphasized together with resonant effects on celestial bodies moving around the Sun.

The following three chapters by A. Cellino, by P. Robutel and J. Souchay, and by M. Birlan deal with the recent improvements in the knowledge of the celestial mechanics of the Solar System and of the extra-Solar System. The discovery and the determination of various asteroid families in the two last decades from both their dynamical features and their physical characteristics constitute a tremendous step in the understanding of the constitution and the evolution of the asteroid belt as well as the Trojans. We explain how numerical integrations at a very large time scale can associate various bodies from a single parent one.

The astrometric space mission Gaia, to be launched in early 2012, will constitute a revolution in the precision of position and velocity determinations of celestial objects among which are the asteroids and the comets. In an extensive chapter Hestroffer, A. dell'Oro, A. Cellino, and P. Tanga present our current understanding relating to astro-photometric measurements and the dynamical properties of these bodies, as well as the dramatic improvements expected from the Gaia mission.
Comets are still a subject of deep investigation concerning their origins and the characteristics of the Oort’s cloud, from which they are assumed to originate. Their dynamical evolution inside the Solar System strongly depends on their possible interactions with the large planets, in particular with Jupiter. A complete review on these objects is given by H. Rickmann. This is followed by a chapter by M. Fouchard explaining in full detail the way by which a perturbation from galactic tides and passing stars can trigger a mechanism leading to deviation of comets toward the inner Solar System.

A large part of the studies in celestial mechanics and dynamical astronomy is based on numerical integration. In an extensive chapter S. Eggl and R. Dvorak present various numerical methods used for solving the gravitational $N$-body problem and discuss their main properties.

Finally, the always-increasing number of recorded stellar systems with their escort of exoplanets leads to the fundamental questions of their dynamical stability as well as the existence of the zones in which conditions for life are gathered. E. Lohinger presents abundant examples of such systems and shows how their dynamical stability can be addressed.

We are sure that the present book will be very useful for any graduate student or specialist aiming at an up-to-date review of the most exciting topics in the fields of celestial mechanics and planetology of solar and extra-Solar Systems.

Both editors thank very strongly the Springer Editorial Board as well as the authors for their acceptance of the work and their nice contributions.

Paris, France
Vienna, Austria

J. Souchay
R. Dvorak
July 2009