Preface

A central core of this textbook has emerged from a series of lectures that were regularly given at Dresden Technical University since 1995. Numerous discussions with international experts in the frame of working groups or international meetings such as those from the series *Les Journées, systèmes de référence spatio-temporels*, that take place every year (with exceptions) in Paris or another European metropolis motivated us to work out the subject of astronomical–geodetical space–time reference systems in detail and to present it in the form of a textbook containing solved exercises and computer programs. It is not difficult to realize that with increasing accuracy in the realization of astronomical spatial–temporal reference systems the complexity of the subject has grown considerably and only a couple of experts worldwide possess some comprehensive view. In the past, it was fairly easy to master concrete problems of astronomical reference systems by means of certain astronomical yearbooks. Now, some of the more significant yearbooks are no longer in print and one expects that every better observatory or relevant national institution has its own software to tackle such practical problems. Many aspects of highly precise spatial–temporal astronomical reference systems exist that need further discussions and international commitments, e.g., by the International Astronomical Union (IAU). In the last decades the subject under discussion underwent drastic changes related with the improvements in measuring accuracy. One aspect is relativity. Today not only the aspect of timescales but also that of spatial coordinates have to be formulated relativistically, i.e., in the framework of Einstein's theory of gravity (GRT), or at least, in the post-Newtonian approximation of GRT.

A central subject of such reference systems is the transformation between some space-fixed, celestial (CRS) and a certain terrestrial reference system (TRS). To this end, traditional elements such as the translational motion of the Earth (Earth–Moon barycenter) in form of the ecliptic, as well as elements related with the rotational motion of the Earth in space (instantaneous rotation pole (IRP), celestial equator), have been introduced. As intermediate quantities in the CRS-TRS transformation, the IRP as well as the intersection between ecliptic and celestial equator (the equinox) historically played a central role. However, with the rapid advance of Very Long Baseline Interferometry (VLBI) for the first time in history a celestial reference system can be realized without reference to the translational and rotational motion of the Earth. This has caused a change of paradigms for the CRS-TRS transformation. The classical rotation pole was meanwhile replaced by some conventional celestial intermediate pole (CIP) and the classical equinox was replaced by some celestial intermediate origin (CIO). After these elements were officially accepted through IAU resolutions the necessity emerges to treat these new paradigms also in textbooks. From all of these reasons, we think that a new textbook devoted to the subject of astronomical spatial–temporal reference systems and frames is of importance, which serves as introduction to the two basic references to the subject: the *IERS Conventions* (IERS C03/C10) and the *Supplement to the Astronomical Almanac.*

For all subjects treated in this volume we offer a series of Maple™ files for the reader to get some feeling for the various models and orders of magnitude. It is obvious that the symbol manipulating language Maple™ is easy to use and has a very attractive graphic surface; however, it is definitively not designed to produce large data sets on a routine basis. The various Maple™ files that the reader may want to download from http://astro.geo.tu-dresden.de/astroref/ merely serve didactical purposes. They were not developed for extensive numerical calculations.

At this place we would like to mention that a few textbooks have appeared recently that cover parts of the central subject. *The Measurement of Time: Time, Frequency and the Atomic Clock* by Audoin and Guinot (2001) provides a comprehensive introduction to the physics of time and time measurement. Many diverse aspects of this book are also treated in *Relativistic Celestial Mechanics of the Solar System* by Kopeikin et al. (2011) where the emphasis clearly lies on the aspect of relativity. Another very useful reference for many parts is Kaplan (2005). The book *Astrometry for Astrophysics: Methods, Models and Applications* by W. van Altena, Cambridge University Press, Cambridge should be published in 2012.

This book (Space-Time Reference Systems) presents an introduction to the problem of astronomical–geodetical space–time reference systems. For the beginner (e.g., students of geodesy or physically oriented sciences) the classical aspects, especially of the spatial coordinates, are introduced very exhaustively for didactical reasons (clearly for experts in the field that part looks very conservative and old-fashioned). We hope that the various (solved) exercises and Maple™ files in the *AstroRef* package support the learning process and provide some insight into orders of magnitude. In this sense the book might serve as an introduction to the IERS Conventions (IERS C03/C10) and the professional astronomical software: SOFA or NOVAS, as discussed in Chap. 10 and the software provided by the IERS. For experts in that field coming from non-relativistic astronomy or space geodesy the book might help to better understand the relativistic aspects related with our central subject.

Finally, it is a pleasure for us to thank the large number of experts who have contributed to this book. Without the many suggestions for improvements, extensions, and actualizations the book would be still in a much poorer state. We especially would like to express our gratitude to Felicitas Arias (BIPM, Paris), Johannes Böhm (TU Vienna), Agnès Fienga (Besancon observatory), Erik Høg (U Copenhagen), Chopo Ma (GSFC), Hervé Manche (Paris observatory),

Jürgen Müller (TU Hannover), Elena Pitjeva (IPA, St.Petersburg), Cyril Ron (Astronomical Institute, Prague), Ulli Schreiber (Wettzell), Harald Schuh (TU Vienna), Irina Tupikova (TU Dresden), Lambert Wanninger (TU Dresden), Norbert Zacharias (USNO), and Sven Zschocke (TU Dresden). We are deeply indebted to the two scientists who likely have contributed most to the problem of space–time reference systems: Nicole Capitaine and Patrick Wallace. They have read practically all parts of the book and suggested a huge number of improvements that we have implemented finally. A large portion of their valuable time went into this book.

Dresden, Germany

Michael Soffel
Ralf Langhans

http://www.springer.com/978-3-642-30225-1

Space-Time Reference Systems
Soffel, M.; Langhans, R.
2013, XIV, 314 p., Hardcover
ISBN: 978-3-642-30225-1