GR 3: Rel. Geodesy

Time: Tuesday 14:15–15:35 Location: ZHG007

GR 3.1 Tue 14:15 ZHG007

Synchronization and Simultaneity in Geodesy — •Bennet Grützner — ZARM, Universität Bremen

A crucial task in geodesy is the synchronization of extended clock networks. For synchronization of these networks a transitive, global notion of simultaneity is needed. As is standard in geodesy and astrophysics, the time coordinate is most commonly used to provide a foliation of space-time into hypersurfaces of simultaneity. Here, we look at the mathematical background and explore the most general formulation of simultaneity in general relativity, extending the concepts used so far. In particular, the differences between time coordinates and synchronization coordinates will be discussed, including some counter-intuitive examples, as well as applications in geodesy such as synchronization with ACES on the ISS.

GR 3.2 Tue 14:35 ZHG007

Chronometry in spacetime: a clock-based global height system — •Dennis Philipp[1,2], Asha Vincent[3], Christian Lisdat[4], and Juergen Mueller[3] — [1]ZARM, University of Bremen, Germany — [2]Faculty of Physics, University of Bremen, Germany — [3]Institute for Geodesy, Leibniz University Hannover, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Ongoing efforts aim at achieving a globally uniform and consistent International Height Reference System as a global standard for accurately determining physical (height-)coordinates across the world. Near the Earth's surface, two stationary standard clocks that are separated by 1 cm in height have a redshift of about 10^{-18} according to Einstein's theory of General Relativity (GR).

We present a definition of clock observables and chronometry in GR, leading towards a relativistic definition of i) a gravity potential, ii) a notion of chronometric height, and iii) generalized geopotential numbers. Clock comparison in this framework allows for accurate height determination in high-performance clock networks, in which frequency differences can be observed between clock sites and corresponding gravity potential differences can be derived. Height values can be represented by geopotential numbers and measured potential differences between clock locations in a dedicated clock network can be used to estimate the transformation parameters between regional reference frames to resolve distortions. A simulation study is presented that focusses on height systems in Europe and South America to demonstrate the potential impact and benefit of clock-based height systems.

GR 3.3 Tue 14:55 ZHG007

General relativistic geodesy: description of GRACE constellations — •Florian Seemann, Eva Hackmann, and Claus Lämmerzahl — ZARM, University of Bremen, Bremen, Germany

For a global coverage of geodetic measurements one has to go to space. The most succesful geodesy missions are the completed GRACE mission and the ongoing GRACE Follow On mission which revealed many unknown facts about the system Earth. Further geodesy missions using intersatellite laser ranging are under development worldwide. With laser ranging changes of the distance between two satellites can be determined better than 1 nm precision. In this presentation a general relativistic description of this type of geodetic measurement is developed. This includes also perturbation forces which originate, e.g., from the atmospheric drag.

GR 3.4 Tue 15:15 ZHG007

Laser Interferometry in Space for Gravity Recovery: Current and Future Missions — •Pallavi Bekal[1,2], Vitali Müller[1,2], Malte Misfeldt[1,2], Martin Weberpals[1,2], Reshma Krishnan Sudha[1,2], Laura Müller[1,2], and Gerhard Heinzel[1,2] — [1]Max Planck Institute for Gravitational Physics (AEI), Hannover, Germany — [2]Leibniz University Hannover (LUH), Hannover, Germany

The Gravity Recovery and Climate Experiment (GRACE) mission's success in measuring the Earth's gravity field provided a path for future twin-satellite gravity missions with more accurate instrumentation. Consequently, after 15 years of operation, GRACE was succeeded by GRACE follow-on (-FO) in 2018. GRACE and GRACE-FO use the conventional microwave instrument (MWI) to measure the distance between the two spacecraft. Since the range is sensitive to the temporal and spatial changes in the Earth's gravity, its measurement calculates global monthly maps of Earth's mass distribution. GRACE-FO, additionally, hosts the first-ever space laser interferometer, the laser ranging interferometer (LRI). The LRI is a technology demonstrator that measures the range of three orders of magnitude more accurately than the MWI, i.e., at the sub-nanometer scale over short timescales. Hence, the future gravity missions GRACE-C(ontinuity) and Next Generation Gravity Mission (NGGM) will only host an evolved LRI-like instrument. We will present our research activities in analysing the LRI data to detect and remove short disturbances, as well as the experiments on the scale factor measurement system (SFMS) and steering mirror (FSM) that improve its implementation for future missions.