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CHALLENGES OF RELATIVISTIC GEODESY

Abstract

In recent years, instruments became such precise that for the interpretation of time and distance measurements and the measurement of the gravitational field effects from Special and General Relativity (GR) have to be taken into account. One of the implications of this development is that the Newtonian geodesy has to be replaced by relativistic geodesy.

One of the first tasks in relativistic geodesy is the general relativistic definition of the geoid. In Newtonian geodesy the geoid is defined as a particular equipotential surface of the sum of the Newtonian gravitational potential and the centrifugal potential which is identical to the mean sea level. This can be experimentally realized by measuring the acceleration of freely falling bodies in e.g. falling corner cubes, superconducting devices or atom interferometers.

This operational procedure can now be taken over to GR. We assume that in a time average the Earth is a rigid body. Within GR it can be shown that the space-time of a rigidly rotating gravitating body with constant rotation and co-rotating forces acting on the constituents is stationary. In a stationary space-time the acceleration of the constituents can be derived from a potential. The particular equipotential surface attached to the mean sea level is the general relativistic geoid.

The gravitational redshift of clocks can also be taken to define a geoid. It has been shown that the redshift defines a so-called redshift potential. This redshift potential can again be taken as geoid. Since this definition gives directly the potential (difference) it shows the superiority of clock measurements compared to acceleration measurements.

It is now very important that it was possible to prove that these two potentials, the acceleration potential as well as the redshift potential, are identical in the case of stationarity of the gravitating body. This has the important consequence, that both data series will yield the same equipotentials and, thus, the same geoid so that both data sets can be combined in order to improve our model of the Earth.

Based on this first definition there are several next steps to be considered, namely the quasi-geoid, the multipole moments of the Earth and how distance and clock measurements from space can determine these multipole moments.

In this talk we will report on our recent achievements in setting up a fully general relativistic framework for geodesy as described above, and give an overview over the open problems to be solved.