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Problems of Potential Theory in Gravity Field Studies

Abstract

In geodesy applications of potential theory are of essential importance. The aim of the paper is to show typical problems that are associated with the solution of Poisson's and Laplace's equation in gravity field studies based on classical terrestrial as well as modern satellite gravity field data. The use of the method of integral equations and the Green's function method is approached first. Problems caused by the complicated topography of the Earth and an oblique derivative in the boundary condition are discussed in this connection. Some techniques, e.g. a transformation of the solution domain, successive approximations etc., that may solve these difficulties and enable the use of the methods, are shown. As an example also Green's function is constructed and its tie to Stokes' kernel is explained. Together with the classical concept of the solution the weak solution and variational methods are discussed in the paper too. The approach is more flexible in general and some of its fundamental properties are mentioned. In contrast to the classical concept the solution is represented by means of a suitable function basis. This leads to Galerkin's approximations and a solution of a rather large system of linear equations. Some examples illustrating the successful use of these methods are sown for basis functions generated by the reproducing kernel in the respective space of harmonic functions. The space is a part of Sobolev's space that in a natural way corresponds to variational methods. Also for the weak formulation steps are discussed that may yield solutions for settings that are very close to physical reality. In the paper possibilities of using the concept of boundary-value problems in the combination of the terrestrial and satellite gravity field data are discussed too. As a rule, however, the problems are

overdetermined by nature. Therefore, an optimization approach has to be applied together with the methods mentioned above. In addition the apparatus of spherical and ellipsoidal harmonics is used for the representation of the solution in this case. Summation techniques then yield the respective integral kernels. When convoluted with the data they show the influence of individual measurements, which in principle also illustrates the tie between the global and the local modeling of the gravity field.