Abstract:

Stream function formulation of surface Stokes equations

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In recent years there has been a strong increase in research on numerical simulation methods for surface (Navier-)Stokes equations. By far most of the papers on numerical methods for surface flow problems treat the (Navier-)Stokes equations in the primitive velocity and pressure variables. In this presentation we treat several aspects related to the surface (Navier-)Stokes equation in streamfunction formulation. We consider a smooth connected (not necessarily simply connected) oriented hypersurface in three-dimensional space without boundary. Appropriate surface gradient, divergence, curl and Laplace operators are defined in terms of the standard differential operators of the ambient Euclidean space. These representations are very convenient for the implementation of numerical methods for surface partial differential equations. A derivation of the surface Helmholtz decomposition and its relation to the surface Hodge decomposition are explained. Based on this Helmholtz decomposition a well-posed stream function formulation of a class of surface Stokes problems is derived. This results in a fourth-order scalar surface PDE for the stream function. A particular finite element method for this stream function PDE is proposed and results of a numerical experiment with this method are presented.