Abstract

We propose a novel immersed method with a non-conforming boundary approach to compute unsteady, incompressible Navier-Stokes flow and non-isothermal fluid problems via the Boussinesq approximation. We term this *the dual boundary and finite element method.* The physical domain is embedded inside a regular grid. The fluid equations are solved through a splitting into homogeneous and inhomogeneous components. The latter is formulated on the regular grid and solved using the finite element method with arbitrary constraints. The regular grid solution is interpolated to the fluid boundary. There, a modified boundary condition is applied to the homogeneous problem so that the combined solution solves the fluid equations, including the boundary constraints. We demonstrate the accuracy of the method using benchmark problems for the Navier-Stokes equations. We subsequently demonstrate the applicability of the method to problems with moving boundaries and discuss future research that may build on the current work.

The main contributions of this work are:

- A detailed description of a novel immersed method that computes accurate solutions to the unsteady, incompressible Navier-Stokes equations and non-isothermal problems via the Boussinesq approximation.
- Application of the method to time-dependent, viscous flow problems with immersed rigid-body motion, including the direct simulation of a sedimenting particle in a fluid-structure algorithm.