

Higher-order ghost finite element methods for Navier-Stokes equations on moving domains

Wednesday, 11 February 2026 16:10 (25 minutes)

In this talk, we present a new numerical technique for approximating solutions of the Navier–Stokes equations in arbitrarily moving domains. The proposed approach relies on a space discretization based on the ghost finite element method (ghost-FEM), which allows computations on unfitted meshes and avoids costly remeshing as the domain evolves in time. Time integration is performed using a high-order implicit-explicit (IMEX) schemes, ensuring robustness and efficiency for incompressible flows. A key contribution of this work is the extension of the finite element formulation to moving domains through an extrapolation strategy based on the Aslam technique. Originally introduced in the context of finite difference methods, this technique is here carefully adapted to the finite element framework to transport and extend the numerical solution across the evolving computational domain. This approach enables a consistent and accurate treatment of the solution in newly activated regions of the mesh while maintaining the stability properties of the underlying discretisation. The error introduced by the geometrical approximation of the moving domain is addressed using the shifted boundary method, which allows an accurate representation of boundary conditions on unfitted meshes. Dirichlet boundary conditions are imposed weakly by means of Nitsche’s method. The associated stabilisation parameter is chosen optimally by solving a generalised eigenvalue problem, ensuring stability and accuracy of the numerical scheme. We present a series of numerical experiments designed to validate the accuracy and convergence properties of the proposed method. The performance of the scheme is further assessed through comparisons with established benchmark problems involving moving boundaries. These results demonstrate the effectiveness of the method in handling complex domain motions while retaining high-order accuracy in both space and time.

Presenter: DILIP, Hridya (University of Catania)