

Summary of the thesis written by Dr. Mikel Landajuela entitled:

COUPLING SCHEMES AND UNFITTED MESH METHODS FOR
FLUID-STRUCTURE INTERACTION

This thesis is devoted to the development and analysis of efficient numerical algorithms for the simulation of mechanical systems involving the interaction of a deformable thin-walled structure with an internal or surrounding incompressible fluid flow.

In the first part, we introduce two new classes of explicit coupling schemes using fitted fluid and solid meshes. The methods proposed combine a certain (parameter free) Robin-consistency in the system with (i) a projection-based time-marching in the fluid or (ii) second-order time-stepping in both the fluid and the solid. The stability properties of the methods are analyzed within representative linear settings. This part includes also a comprehensive numerical study in which state-of-the-art coupling schemes (including some of the methods proposed herein) are compared and validated against the results of an experimental benchmark.

In the second part, we consider unfitted mesh formulations. These approaches are more versatile at simulating problems with large interface deflections and/or topological changes. The spatial discretization in this case is based on variants of Nitsche's method with cut elements. Robustness with respect to arbitrary interface intersections is guaranteed through suitable stabilization. For a fictitious domain setting using overlapping meshes, we present two new classes of splitting schemes which exploit the aforementioned interface Robin-consistency in the unfitted framework. The semi-implicit or explicit nature of the splitting in time is dictated by the order in which the spatial and time discretizations are performed. In the case of the coupling with immersed structures, weak and strong discontinuities across the interface are allowed for the velocity and pressure via the XFEM method. Stability and error estimates are provided, using energy arguments within a linear setting. A series of numerical tests, involving static and moving interfaces, illustrates the performance of the different methods proposed.