6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

# AN OVERLAPPING DOMAIN METHOD FOR HEMODYNAMICS BASED ON WEIGHTED SUMS

**Maximilian Balmus**[1,*], **David A. Nordsletten**[1]

[1] School of Biomedical Engineering and Imaging Scieneces, King's College London, St Thomas' Hospital, Westminster Bridge Road, London, SE1 7EH, maximilian.balmus@kcl.ac.uk, david.nordsletten@kcl.ac.uk

**Keywords**: *Computational Fluid Dynamics, FEM, Overlapping Domains*

Balancing solution accuracy and computational feasibility remains significant challenge in solving fluid flow problems; particularly in cases where the domain undergoes large deformations. Arguably, the most challenging example in biomedical applications occurs for cardiac valves, which move significantly through the ventricular chambers, as well as pulmonary and aortic roots. Currently, the most widespread approach for this class of problems are the immersion methods. While moving mesh techniques (i.e. ALE) can suffer from large element distortions, in popular immersion methods the mesh is kept fixed, eliminating mesh distortion or the need for re-meshing. This comes at the cost of poor stress and pressure estimations on the boundary surface. Chimera methods aim to combine the advantages of the two approaches. Generally, the setup consists of two overlapping meshes: one global and the other embedded, enveloping the surface of the immersed body. This creates a conforming interface between the fluid and solid, while it diminishes mesh distortions. However, it introduces an artificial non-conforming fluid-fluid interface, resulting in a discontinuous flow solution at the transition between domains.

In this paper, we introduce an overlapping domains techinque where fluid velocity and pressure function spaces are defined as the weighted sum of the functions which can be represented on distinct sub-meshes. Thus, while we retain the main advantages of the chimera method, we introduce greater flexibility on how the fluid-fluid coupling is achieved. Most significantly, $C^0$ continuity can be obtained at the interface by choosing the embedded function weight to be zero on this surface, irrespective of the resolutions used to represent the domains. To assess the accuracy of this approach, we consider a series of test cases of increasing complexity. Spatio-temporal convergence is shown to be optimal and comparable with those of boundary fitted and ALE approaches. For transient flows, we demonstrate that the technique can be used to accurately estimate parameters that define the system in the case of the Schäfer-Turek benchmark. Finally, we apply the method to solve a more realistic 3D problem for fluid flow around a moving cardiac valve.