

## **IMMERSED BOUNDARY VARIATIONAL METHODS: THEORY, DATA STRUCTURES, AND APPLICATIONS**

**TRACK NUMBER 100 – ADVANCED DISCRETIZATION TECHNIQUES**

**ALEXANDER DÜSTER<sup>1</sup>, JOHN A. EVANS<sup>2</sup>,  
BASKAR GANAPATHYSUBRAMANIAN<sup>3</sup>, MING-CHEN HSU<sup>3</sup>, MATS LARSON<sup>4</sup>,  
ERNST RANK<sup>5</sup>, GUGLIEMO SCOVAZZI<sup>6</sup>, AND JINHUI YAN<sup>7</sup>**

<sup>1</sup>Hamburg University of Technology, <sup>2</sup>University of Colorado Boulder, <sup>3</sup>Iowa State University, <sup>4</sup>Umea University, <sup>5</sup>Technical University of Munich, <sup>6</sup>Duke University, <sup>7</sup>University of Illinois at Urbana-Champaign

**Keywords:** Fictitious Domain Methods, Embedded Domain Methods, Variational Methods

### **ABSTRACT**

Immersed Boundary Methods have garnered significantly increased attention over the past ten to fifteen years. Their central principle involves extending the domain of computation to a larger one, typically with a simple shape that is easy to mesh. On this extended domain, a finite element-type computation is performed, distinguishing between regions interior and exterior to the original domain. Known under terms like fictitious domain or embedded domain methods, this central principle has been in use since the 1960s. Recent renewed interest is driven by innovative, efficient algorithmic developments and mathematical analyses showing optimal convergence despite the presence of cut elements. Additionally, the compatibility of these methods with various geometric models and their application to many new engineering challenges have contributed to their popularity. Numerous variational versions of Immersed Boundary Methods have been developed, such as CutFEM, the Finite Cell Method, Unfitted Finite Elements, the Shifted Boundary Method, Phi-FEM, and Immersogeometric Analysis, to name a few.

This minisymposium will focus on variational types of Immersed Boundary Methods. Key topics include mathematical analysis, adaptivity, advanced quadrature, data structures, and parallel scaling of algorithms, along with integration with CAD models and non-standard geometric representations, and applications. The scope of this minisymposium is broad, including applications in solid mechanics, heat transfer, CFD, fluid/structure interaction, and other types of domain coupling. Additionally, the connection between Immersed Boundary Methods and meta-algorithms, such as those used in Uncertainty Quantification, Reduced Order Models, Machine Learning and Artificial Intelligence, Direct and Inverse Problems, and Topology Optimization, among others, will be addressed.