Formulation and Performance Study of an Immersed Boundary Method Based on a Hierarchical B-Spline Grid

W. G. Dettmer, C. Kadapa and D. Perić

College of Engineering, Swansea University
Singleton Park, Swansea SA2 8PP, UK

w.g.dettmer@swansea.ac.uk, c.kadapa@swansea.ac.uk, d.peric@swansea.ac.uk

ABSTRACT

A computational strategy for the simulation of incompressible fluid-structure interaction is presented which is suitable for problems featuring large structural deformations and topology changes as well as large added mass effects. It is based on an immersed boundary method formulated on a hierarchical B-spline grid. Along the immersed interfaces, the kinematic consistency of the fluid and the solid phases may be enforced by means of Lagrangian multipliers or Nitsche's method. It is a key feature of the strategy that the inactive or cut cells of the fluid background grid are not modified or switched off, but remain part of the computational domain. This approach affects the ideal choice of pressure and velocity basis functions and its advantages and disadvantages are discussed. A monolithic solution procedure is employed which features good convergence rates. The performance of the strategy is demonstrated by a number of benchmark problems featuring external as well as internal flow.

The focus of this presentation is on the modelling of the immersed interfaces and on the sharpness of the discontinuities that can be achieved with this approach. The effectiveness of the hierarchical refinement is highlighted.