A review on immersed boundary methods for fluid-structure interaction

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Abstract

Interactions between fluid flows and the immersed solids therein are nonlinear phenomena that have important applications to a wide range of scientific and engineering disciplines. In this review, immersed boundary (IB) methods for fluid-structure interaction (FSI) of rigid or elastic bodies are introduced. IB methods impose momentum forcing on an Eulerian mesh to satisfy boundary conditions on the interface between fluid and structure, which enables us to use a non-body conforming grid system for complex shaped moving bodies. Imposition of the momentum forcing is performed directly through discrete delta function or indirectly through velocity reconstruction, by which IB methods have their own strengths and weaknesses to FSI problems of rigid and elastic bodies. To deal with FSI, IB methods using monolithic and partitioned approaches with different stability and cost have been suggested. We will also emphasize mainly on the recent developments in the field, including IBMs for turbulent flows and compressible fluids/solids, structured or unstructured adaptive grid, and higher order schemes. Nevertheless, there are some important problems, such as cases of low density ratio of solid to fluid and turbulent flow for very high Reynolds number, which have not been completely overcome by current IB methods in terms of the stability, accuracy and cost.