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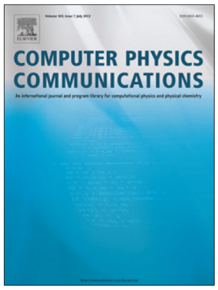

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Cheng Liu, Changhong Hu

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Block-Based Adaptive Mesh Refinement for Fluid Structure Interactions in Incompressible Flows

Cheng Liu[1,*], Changhong Hu[*]

[*]*Research Institute for Applied Mechanics, Kyushu University, Fukuoka 816-0811, Japan*

Abstract. In this study, an immersed boundary (IB) approach on the basis of moving least squares (MLS) interpolation is proposed for analyzing the dynamic response of a rigid body immersed in incompressible flows. An improved mapping strategy is proposed for a quick update of the signed distance field. A CIP–CSL (constraint interpolation profile - semi-Lagrangian) scheme with a compact stencil is adopted for the convective term in momentum equation. Fluid-structure interaction problems can be solved by either the weak or the strong coupling schemes according to the density ratio of the solid and fluid. This research is based on our previous studies on block-structured adaptive mesh refinement (AMR) method for incompressible flows (Liu and Hu, *J. Comput. Phys.*, 359 (2018), 239-262). Present AMR-FSI solver is proved to be accurate and robust in predicting dynamics of VIV (vortex induced vibration) problems. The efficiency of the adaptive method is demonstrated by the 2D simulation of a freely falling plate with the comparison to other numerical methods. Finally, the freely falling and rising 3D sphere are computed and compared with corresponding experimental measurement.

Keywords: Fluid-structure interaction, CIP-CSL; Adaptive mesh; MLS interpolation; Immersed boundary method; Incompressible flows.

1. Introduction

Fluid-structure interaction (FSI) problems are important in many engineering and scientific fields. Although comprehensive studies on numerical simulations of such problems have been made, challenges still remain due to the complicated nonlinear interaction between the solid and fluid. From the prospective of numerical simulation, the dynamic status of the structure depends on the surrounding fluid, while the flow fields must be calculated by considering of the structure motion simultaneously. Such coupled system can be solved by two different approaches, the monolithic [1] and partitioned methods [2-6]. The latter is more flexible since the fluid and structure can be solved separately, by using different numerical methods. In this study only the partitioned method is taken into consideration. The partitioned methods can be classified into two types, the weak-coupling scheme [2-3] and the strong-coupling scheme [4-6]. The former solves the fluid equation and dynamic equation of the structure alternatively.

[1] Corresponding author. *Email addresses:* liu@riam.kyushu-u.ac.jp (C. Liu), hu@riam.kyushu-u.ac.jp (C. Hu)