A stencil penalty approach for improving accuracy of constraint immersed boundary method.

Rahul Bale*, Niclas Jansson*, Keiji Onishi*, Makoto Tsubokura*,†, and Neelesh Patankar‡

* RIKEN, AICS
Minatojima-minami-machi, Chuo-Ku, Hyogo, Japan
e-mail: rahul.bale@riken.jp, leifniclas.jansson@riken.jp ,
keiji.onishi@riken.jp.

† Department of Computational Science,
Kobe University,
Kobe, Hyogo, Japan.
e-mail: mtsubo@riken.jp

‡ Department of Mechanical Engineering,
Northwestern University,
Evanston, Illinois, USA
e-mail: n-patankar@northwestern.edu

ABSTRACT

The constraint based immersed boundary (cIB) method has been shown to be accurate between low and moderate Reynolds number (Re) flows [1, 2]. While cIb is moderately accurate for immersed bodies of finite thickness at high Re, in our studies we found that cIB is unable to produce accurate results at high Re when the thickness of immersed bodies is less than mesh resolution. Many industrial scale applications involve geometries whose thickness so small that it cannot be resolved in a computationally cost effective simulation. In our study we investigate the source of the inaccuracies in cIB method and propose new formulation to that is more accurate at high Re for very thin or zero-thickness immersed bodies.

In our investigation we found that the high Re flows typically result in large pressure gradient across fluid-IB interface (when the IB interface is of zero-thickness). As a consequence of the pressure jump, pressure gradient is incorrectly evaluated near the fluid-IB interface. This leads to inaccuracies in the boundary layer around the IB and, in severe cases, leakage of flow across the fluid-IB interface. A numerical formulation that avoids the jump in pressure through a modified pressure gradient operator will be presented. The pressure gradient operator is modified through a WENO based stencil penalization [3]. The numerical method is evaluated through simulation of flow past a sphere at Re around drag crisis. It is found that the numerical method is able to produce significantly more accurate results compared to cIB method.

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