Accepted Manuscript

An advanced moving particle semi-implicit method for accurate and stable simulation of incompressible flows

Xiaoxing Liu, Koji Morita, Shuai Zhang

PII: S0045-7825(18)30240-8
DOI: https://doi.org/10.1016/j.cma.2018.05.005
Reference: CMA 11906

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 7 December 2017
Revised date : 1 May 2018
Accepted date : 3 May 2018

Please cite this article as: X. Liu, K. Morita, S. Zhang, An advanced moving particle semi-implicit method for accurate and stable simulation of incompressible flows, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.05.005

An advanced moving particle semi-implicit method for accurate and stable simulation of incompressible flows

Xiaoxing Liu[a], Koji Morita[a] and Shuai Zhang[b]

[a] Department of Applied Quantum Physics and Nuclear Engineering, Kyushu University
744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan

[b] School of Aeronautics and Astronautics, Zhejiang University
38 Zheda Road, Hangzhou, Zhejiang 310027, China

Abstract

An advanced moving particle semi-implicit (MPS) method for the simulation of incompressible flows that provides enhanced accuracy and stability is proposed. Up to now, existing high-order accurate MPS pressure gradient schemes suffer from instability produced by attractive pressure gradient while some stabilized pressure gradient schemes have the shortcomings of large discretization error. We propose a high-order stabilized gradient model in which first-order Taylor-series consistency is ensured and stability is guaranteed by purely repulsive pressure gradient. Laplacian model and divergence model are modified and enable accurate and stable solution for the pressure Poisson equation (PPE). The proposed MPS scheme provides a more accurate and stable simulation of incompressible flows. Several two-dimensional numerical simulations are presented to demonstrate the enhanced performance of the proposed MPS method.

Keywords:
MPS method; Particle method; Accuracy; Gradient model; Laplacian model

1. Introduction

Particle methods have been proven to be useful in the simulation of incompressible flows. They are suitable for simulations of free-surface incompressible flows and multi-phase flows. The shape of the surface and interface is directly obtained from the set of computational particles. As a result, no additional effort is necessary to capture or track the interface, and the free surface or interface is always represented clearly in these particle-based methods. Typical particle methods include the smoothed particle hydrodynamics (SPH) method [1], moving particle semi-implicit (MPS) method [2] and