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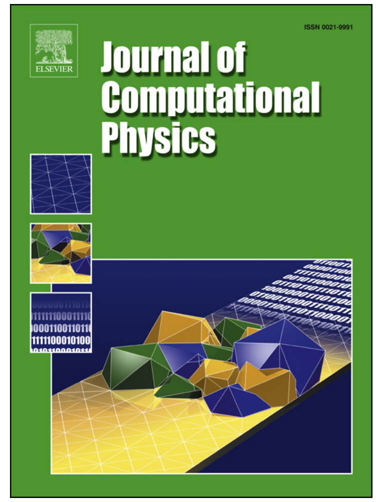

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A Robust Two-Node, 13 Moment Quadrature Method of Moments for Dilute Particle Flows Including Wall Bouncing

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Abstract

For flows where the particle number density is low and the Stokes number is relatively high, as found when sand or ice is ingested into aircraft gas turbine engines, streams of particles can cross each other's path or bounce from a solid surface without being influenced by inter-particle collisions. The aim of this work is to develop an Eulerian method to simulate these types of flow. To this end, a two-node quadrature-based moment method using 13 moments is proposed. In the proposed algorithm thirteen moments of particle velocity, including cross-moments of second order, are used to determine the weights and abscissas of the two nodes and to set up the association between the velocity components in each node. Previous Quadrature Method of Moments (QMOM) algorithms either use more than two nodes, leading to increased computational expense, or are shown here to give incorrect results under some circumstances. This method gives the computational efficiency advantages of only needing two particle phase velocity fields whilst ensuring that a correct combination of weights and abscissas are returned for any arbitrary combination of particle trajectories without the need for any further assumptions. Particle crossing and wall bouncing with arbitrary combinations of angles are demonstrated using the method in a two-dimensional scheme. The ability of the scheme to include the presence of drag from a carrier phase is also demonstrated, as is bouncing off surfaces with inelastic collisions. The method is also applied to the Taylor-Green vortex flow test case and is found to give results superior to the existing two-node QMOM method and in good agreement with results from Lagrangian modelling of this case.

Key words: Multiphase flow; Eulerian method; QMOM; particle bouncing.

1. Introduction

The physical phenomenon of particle wall-bouncing is important for dilute, dispersed multiphase flows in a variety of applications for which numerical simulations are required. For example, when turbomachinery operates in sandy or dusty environments it is important to be able to predict accurately the rate at which particles impact on components in order to predict the rate of erosion or deposition [1] [2]. Another example is the build-up of ice both inside and outside of aircraft engines which is a matter of concern to the aviation industry. Predictions of ice accretion in such cases rely on

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