A unified implicit scheme for kinetic model equations. Part I. Memory reduction technique

Songze Chen, Chuang Zhang, Lianhua Zhu, Zhaoli Guo

PII: S2095-9273(16)30621-1
DOI: http://dx.doi.org/10.1016/j.scib.2016.12.010
Reference: SCIB 20

To appear in: *Science Bulletin*

Please cite this article as: S. Chen, C. Zhang, L. Zhu, Z. Guo, A unified implicit scheme for kinetic model equations. Part I. Memory reduction technique, *Science Bulletin* (2016), doi: http://dx.doi.org/10.1016/j.scib.2016.12.010

A unified implicit scheme for kinetic model equations. Part I. Memory reduction technique

Songze Chen[a], Chuang Zhang[a], Lianhua Zhu[a], Zhaoli Guo[a]

[a]*State Key Laboratory of Coal Combustion, School of Energy and Power Engineering, Huazhong University of Science and Technology, Wuhan 430074, China*

Abstract

A memory reduction technique is proposed for solving stationary kinetic model equations. As implied by an integral solution of the stationary kinetic equation, a velocity distribution function can be reconstructed from given macroscopic variables. Based on this fact, we propose a technique to reconstruct distribution function at discrete level, and employ it to develop an implicit numerical method for kinetic equations. The new implicit method only stores the macroscopic quantities which appear in the collision term, and does not store the distribution functions. As a result, enormous memory requirement for solving kinetic equations is totally relieved. Several boundary conditions, such as, inlet, outlet and isothermal boundaries, are discussed. Some numerical tests demonstrate the validity and efficiency of the technique. The new implicit solver provides nearly identical solution as the explicit kinetic solver, while the memory requirement is on the same order as the Navier-Stokes solver.

Keywords: Implicit scheme, Kinetic equation, Memory reduction

Received: 08-Nov-2016

Revised: 11-Dec-2016

Accepted: 13-Dec-2016

Contribution type: Article

1. Introduction

To solve rarefied gas flows, the most commonly used numerical methods are probabilistic methods, such as the direct simulation Monte Carlo (DSMC) [1] method, and kinetic methods, such as the direct solver for Boltzmann equation [2, 3]. Both methods describe the gas motion from the microscopic or mesoscopic view. The number of unknowns of the system is much larger than that from a macroscopic view. Generally speaking, to depict the rarefied flow properly, in addition to the physical space (3 independent coordinates), another extra three-dimensional velocity space must be considered. Hence, the degree of freedom of the

*Corresponding author
Email address: jacksongze@hust.edu.cn (Songze Chen)