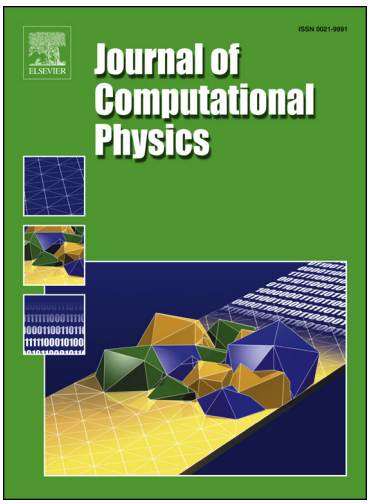
Accepted Manuscript



A hierarchical uniformly high order DG-IMEX scheme for the 1D BGK equation

Tao Xiong, Jing-Mei Qiu

PII: S0021-9991(17)30048-7
DOI: http://dx.doi.org/10.1016/j.jcp.2017.01.032
Reference: YJCPH 7094

To appear in: *Journal of Computational Physics*

Received date: 3 May 2016
Revised date: 15 January 2017
Accepted date: 17 January 2017

Please cite this article in press as: T. Xiong, J.-M. Qiu, A hierarchical uniformly high order DG-IMEX scheme for the 1D BGK equation, *J. Comput. Phys.* (2017), http://dx.doi.org/10.1016/j.jcp.2017.01.032

A Hierarchical Uniformly High Order DG-IMEX Scheme for the 1D BGK Equation [1]

Tao Xiong [2] and Jing-Mei Qiu[3]

Abstract

A class of high order nodal discontinuous Galerkin implicit-explicit (DG-IMEX) schemes with asymptotic preserving (AP) property has been developed for the one-dimensional (1D) BGK equation in Xiong et. al. (2015) [40], based on a micro-macro reformulation. The schemes are globally stiffly accurate and asymptotically consistent, and as the Knudsen number becomes small or goes to zero, they recover first the compressible Navier-Stokes (CNS) and then the Euler limit. Motivated by the recent work of Filbet and Rey (2015) [27] and references therein, in this paper, we propose a hierarchical high order AP method, namely kinetic, CNS and Euler solvers are automatically applied in regions where their corresponding models are appropriate. The numerical solvers for different regimes are coupled naturally by interface conditions. To the best of our knowledge, the resulting scheme is the very first hierarchical one being proposed in the literature, that enjoys AP property as well as uniform high order accuracy. Numerical experiments demonstrate the efficiency and effectiveness of the proposed approach. As time evolves, three different regimes are dynamically identified and naturally coupled, leading to significant CPU time savings (more than 80% for some of our test problems).

Keywords: A hierarchical scheme, Compressible Euler equations, Compressible Navier-Stokes equations, Asymptotic Preserving, Nodal Discontinuous Galerkin, High order, IMEX, BGK equation

[1]Research supported by NSF DMS-1217008, DMS-1522777 and Air Force Office of Scientific Computing FA9550-16-1-0179, the Fundamental Research Funds for the Central Universities No. 20720160009, NSFC grant 11601455, NSAF grant U1630247 and NSF grant of Fujian Province 2016J05022, and the Marie Skłodowska-Curie Individual Fellowships H2020-MSCA-IF-2014 of the European Commision, under the project HNSKMAP 654175.

[2]School of Mathematical Sciences, Fujian Provincial Key Laboratory of Mathematical Modeling and High-Performance Scientific Computing, Xiamen University, Xiamen, Fujian, P.R. China, 361005. Currently visiting at the Université de Toulouse III, UMR 5219, Institut de Mathématiques de Toulouse, 118 route de Narbonne, F-31062 Toulouse cedex, France. Email: txiong@xmu.edu.cn

[3]Department of Mathematics, University of Houston, Houston, 77004. E-mail: jingqiu@math.uh.edu.