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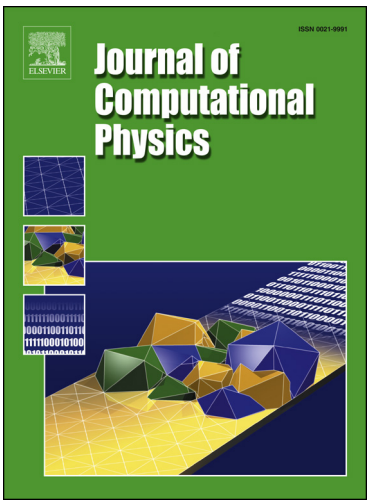

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PII: S0021-9991(17)30626-5
DOI: http://dx.doi.org/10.1016/j.jcp.2017.08.045
Reference: YJCPH 7547

To appear in: *Journal of Computational Physics*

Received date: 23 November 2016
Revised date: 10 June 2017
Accepted date: 22 August 2017

Please cite this article in press as: Z. Wang et al., Unified gas-kinetic scheme for diatomic molecular flow with translational, rotational, and vibrational modes, *J. Comput. Phys.* (2017), http://dx.doi.org/10.1016/j.jcp.2017.08.045

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Unified Gas-kinetic Scheme for Diatomic Molecular Flow with Translational, Rotational, and Vibrational Modes

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Abstract

The unified gas-kinetic scheme (UGKS) is a direct modeling method for both continuum and rarefied flow computations. In the previous study, the UGKS was developed for diatomic molecular simulations with translation and rotational motions. In this paper, a UGKS with non-equilibrium translational, rotational, and vibrational degrees of freedom, will be developed. The new scheme is based on the phenomenological gas dynamics model, where the translational, rotational, and vibrational modes get to the equilibrium with different time scales with the introduction of rotational and vibrational collision numbers. This new scheme is tested in a few cases, such as the homogeneous flow relaxation, shock structure, shock tube problem, and flow passing through a circular and semi-circular cylinders. The analytical and DSMC solutions are used for the validation of the UGKS, and reasonable agreements have been achieved.

Keywords: `unified gas-kinetic scheme, diatomic molecules, vibrational relaxation, non-equilibrium hypersonic flows`

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