JH250073

AI-leveraged Multiscale Scheme for Kinetic Equations

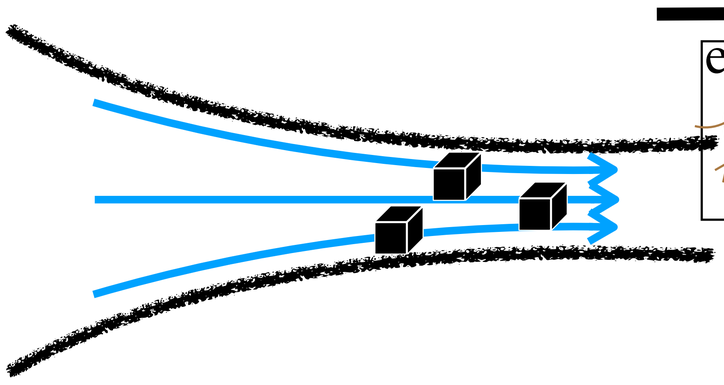
Collaboration in Germany & Japan: S. Yasuda, R. Numata (U. Hyogo),
T. Shigeru, M. Hattori (Kyoto U.), M. Frank, J. Hörter (KIT)

Multiscale High order/Low order (HOLO) Algorithm

- W. Taitano, et. al., “Moment-based acceleration for neutral gas kinetics with BGK collision operator”, J. Compt. Theor. Trans, (2014)
- Chacón, et. al., “Multiscale High-order/Low-order (HOLO) Algorithms and ApplicationsJ. Compt. Phys. (2017)

Lo Res.

$(\rho^{\mathrm{Lo}}, u^{\mathrm{Lo}}, T^{\mathrm{Lo}})$

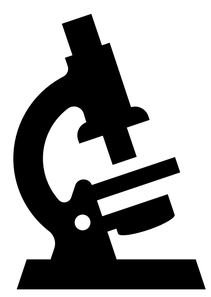


$$\partial_t \begin{pmatrix} \rho \\ u \\ T \end{pmatrix} = \mathrm{div}\vec{J}^{\mathrm{Hi}}$$

FEM, FVM, FFT, LU, etc.

Efficient & Well Established

Hi Res.



$$f(t, x, \xi)$$

$$\partial_t f + v \cdot \nabla_x f = J(f, f)$$

FD, DSMC, AP scheme.,etc.

Huge Memory
Microscopic Interaction

$\vec{J}^{\mathrm{Hi}}[f]$

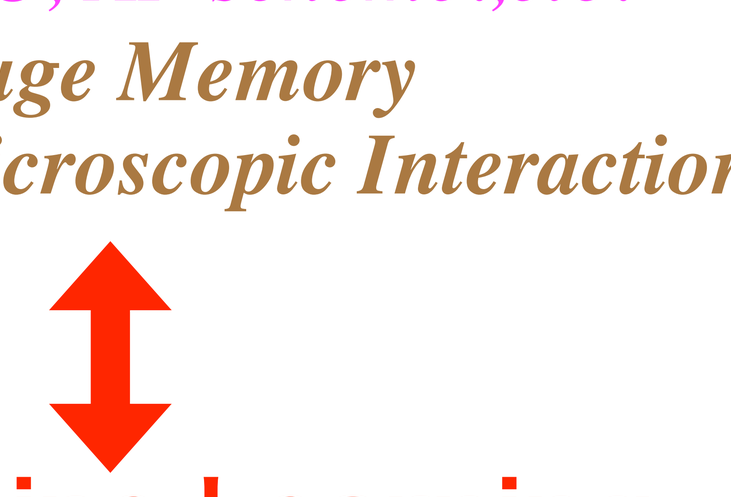
$\vec{J}^{\mathrm{AI}}[f]$

Machine Learning on Boltzmann $J(f, f)$

Agenda

- **Discussion in person @ KIT in June**
- **Formulation will finish by August**
- **Coding for 1D from September**
- **Benchmark for 1D gas flows for This year !**
- **Extension to 2D gas flows and others**

Osaka U. SQUID



AI Boltzmann collision operator:

- Xiao and Frank, “Using neural networks to accelerate the solution of the Boltzmann equation”, J. Comput. Phys. (2021)
- Xiao and Frank, “RelaxNet: A structure-preserving nueral network to approximate the Boltzmann collision operator”, J. Comput. Phys (2023)