Research Report

# DSMC vs. LBM Slip Model

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# Presentation Outline

- A review of DSMC / LBM slip models
- DSMC channel flow data
- DSMC / LBM slip comparison
- Conclusion and future work

# Motivation – Gas Flow through Tight Pores

- Knudsen number – Kn = λ / L
  - Kn < 0.001 – Navier Stokes + no-slip boundary
  - 0.001 < Kn < 0.1 – slip flow regime
    - Flow may be described by Navier-Stokes equation for the bulk + slip boundary condition
  - 0.1 < Kn < 10 – transitional flow regime
  - 10 < Kn – free molecular flow regime

Lattice Boltzmann

DSMC – direct simulation Monte Carlo

**Objective: Verify LB simulation with DSMC**

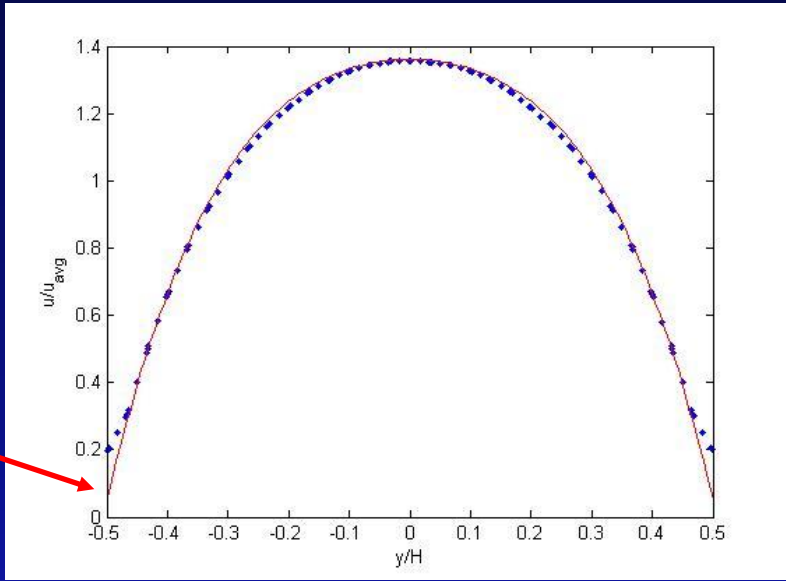
# List of DSMC Simulations

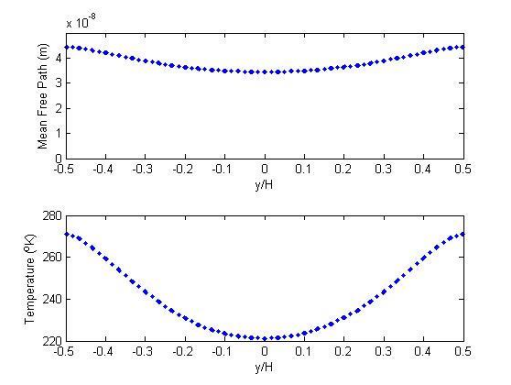
- Provided by Craft Tech. in November 2014
  - Rarefied flow of $N_2$ through a 2D channel
  - Five Knudsen numbers – **0.0064, 0.0399, 0.0845, 0.120, 0.171**
  - Tangential momentum accommodation = 1 (diffusive wall)
  - Flow is low speed and has no significant density variation
- They are used to verify
  - There is a slip near the wall
  - LBM + Maxwell slip can predict the flow

# Kn = 0.0064

- This case has slight temperature variations in the channel
- Parabolic profile is a good fit to DSMC data ($R^2$ = 0.97)
- LBM + slip (red line) reproduces DSMC results very well

Very low slip length; note DSMC slightly off parabolic near the wall

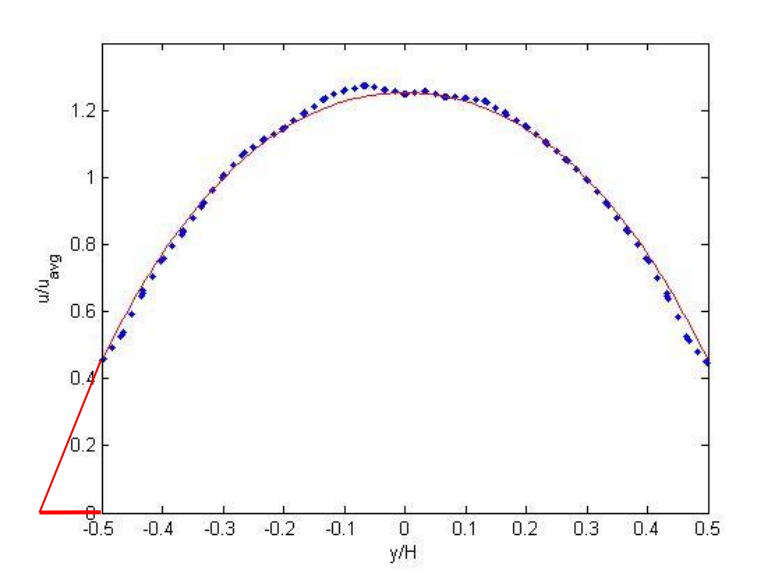


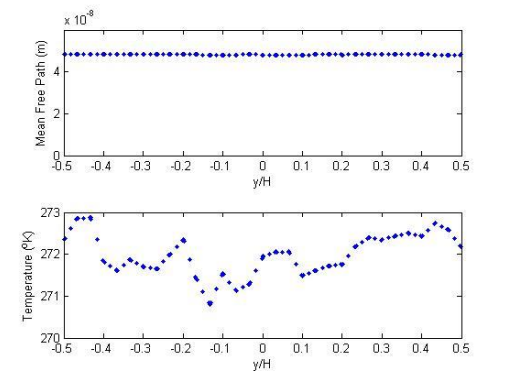



# Kn = 0.120

- This case is nearly isothermal
- Parabolic profile is a good fit to DSMC data ($R^2$ = 1.00)
- LBM + slip (red line) reproduces DSMC results very well

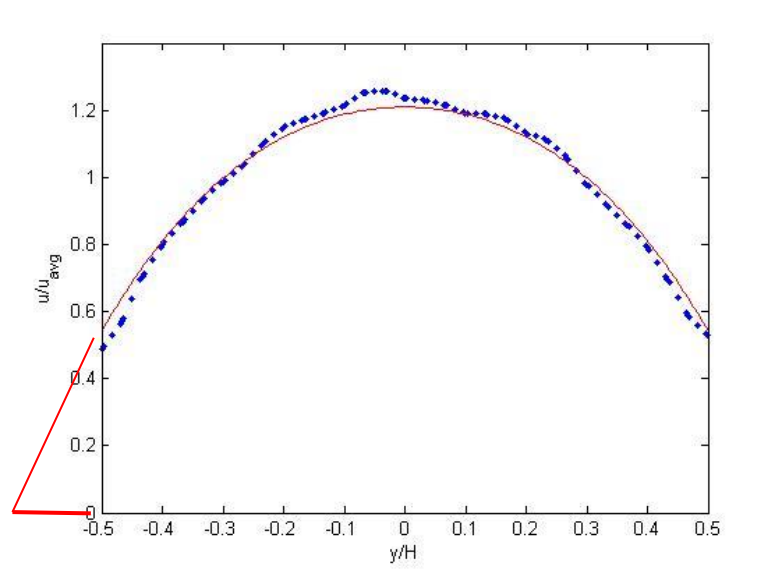
Slip length

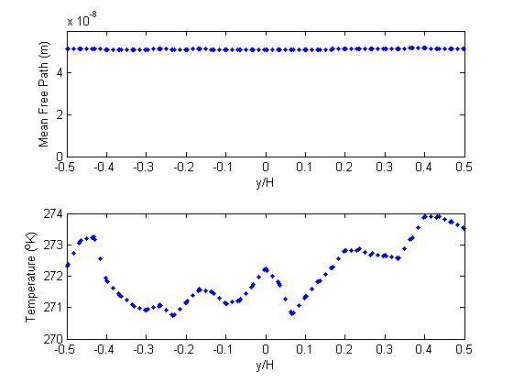


# Kn = 0.171

- This case is nearly isothermal
- Deviation from parabolic profile starts to appear ($R^2 = 0.97$)
- LBM + slip (red line) starts to show deviation from DSMC data



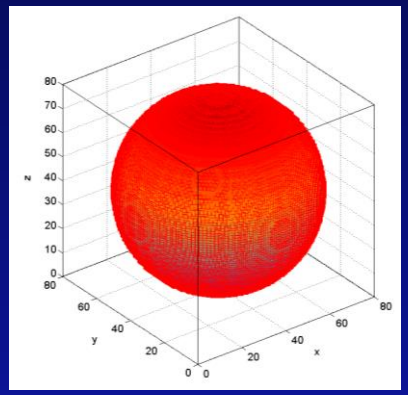



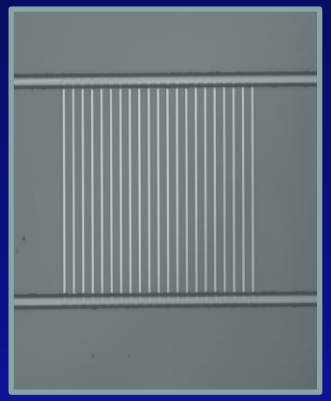
# Discussion

1. From Kn = 0.0064 to 0.120, DSMC profiles are very close to parabolic – this shows that gas flow for this geometry and in this Kn regime can be modeled by NS + slip boundary
2. From Kn = 0.0064 to 0.120, LB + Maxwell slip model is in very good agreement with DSMC

# Future Work – Nanoscale Flow

1. Verify LB + Maxwell in periodic array of spheres to establish its usefulness for low Kn flows
2. Conduct DSMC for high Kn flows through porous medium models
3. Conduct gas / liquid flow experiments



LB + slip method reference:

Wang, Simulation of Slip Flow and Phase Change in Nanopores, PhD Dissertation, Colorado School of Mines, 2014

**Thank You & Questions**