Rarefied Hypersonic and Micro/Nanoscale Gas Flows and Heat Transfer

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Research goal
Pushing the limit of conventional gas dynamics (Navier-Stokes theory) based on new constitutive relations

Nonlinear Coupled Constitutive Relations (NCCR) and Langmuir slip models
- A unified framework for rarefied and micro/nanoscale gases
- Validated for various benchmark problems

Developing an efficient computational model for rarefied and micro/nanoscale gases

Combination of conservation laws and NCCR
- Aiming at replacing computationally inefficient DSMC in transition regimes
- Low computational cost comparable with NS codes
- Successfully applied to two-dimensional hypersonic flow

Applications of new models to hypersonic vehicles and micro/nano devices

Prediction of aerothermodynamic coefficients (bridging formula)
- Aerodynamic characteristics of reentry space vehicles
- New theory of force-driven microscale Poiseuille gas flows based on non-Fourier law

Milestones
New nonlinear coupled constitutive relations (NCCR)

Stress

Thermodynamic force

Velocity shear gas flow
Compression-expansion gas

New Langmuir slip model

\[ K = \frac{C_v}{C_sC_l} = \frac{N\alpha}{1 + \beta \rho} \]

where \( \beta = \frac{k_B T_m}{k_B T_w} \)

The fraction of gas molecules at thermal equilibrium

Dissemination of research outcomes
Journal of Fluid Mechanics (Cambridge; 2009)
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