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

Funding

Domestic

Korea Research Foundation	(2005~2011)
DRC for Aerospace Green Technology	(2009~2012)
Korea Science and Engineering Foundation	(1999~2006)

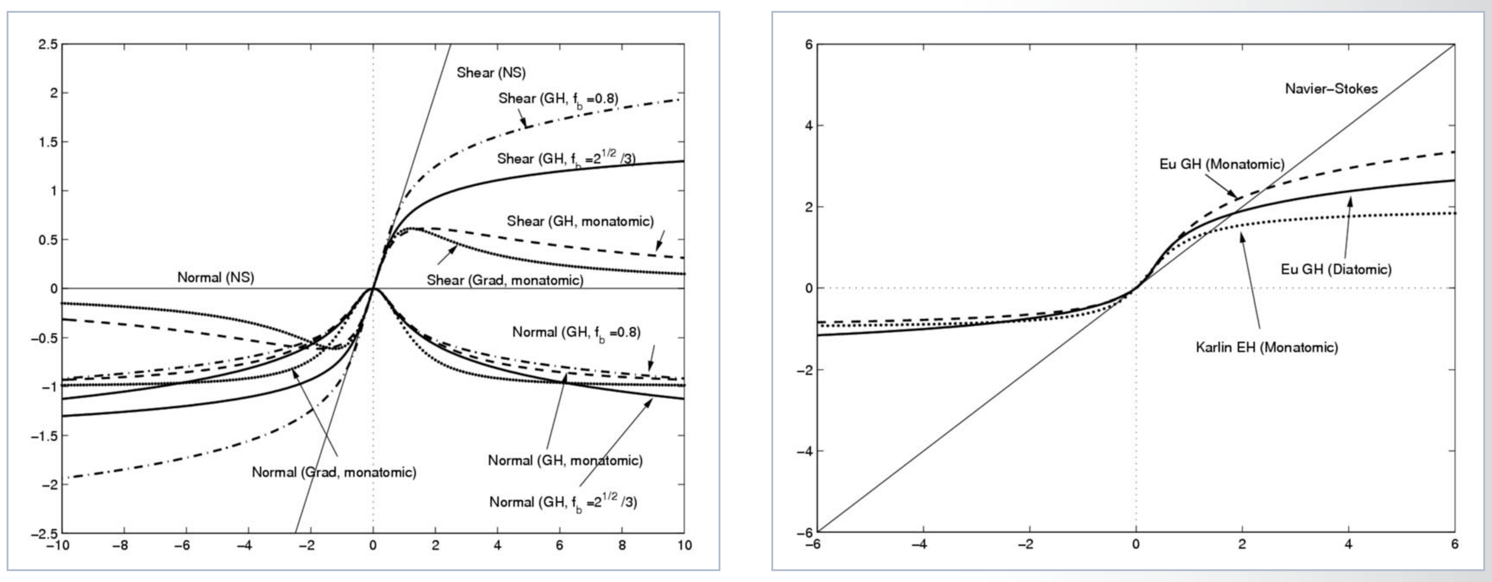
Foreign

US NASA (2004~2006)
UK EPSRC (2004~2006)

Milestones

New nonlinear coupled constitutive relations (NCCR)

Stress



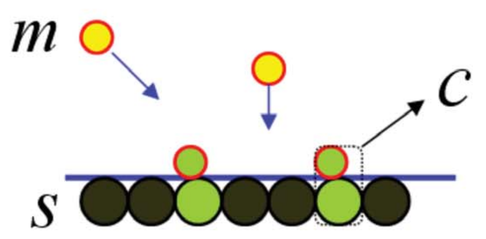
Thermodynamic force

Velocity shear gas flow　　Compression-expansion gas

New Langmuir slip model

$$K = \frac{C_c}{C_m C_s} = \frac{N\alpha}{[p/k_B T_w] N(1-\alpha)},$$

$$\alpha = \frac{\beta p}{1+\beta p} \quad \text{where} \quad \beta = \frac{K}{k_B T_w}.$$



$m + s \Rightarrow c$

The fraction of gas molecules at thermal equilibrium

Dissemination of research outcomes

Journal of Computational Physics (Elsevier; 2001,2004)
Physics of Fluids (AIP; 1999, 2004, 2005, 2009, 2010)
Journal of Fluid Mechanics (Cambridge; 2009)
International Journal of Heat and Mass Transfer (Elsevier; 2006)
Shock Waves (Springer; 2008 A, B)
Continuum Mechanics and Thermodynamics (Springer; 2009)

Collaborators

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