# A Phase-Space Coupled Hybrid Framework for Combined Continuum/Rarefied High Speed Flows

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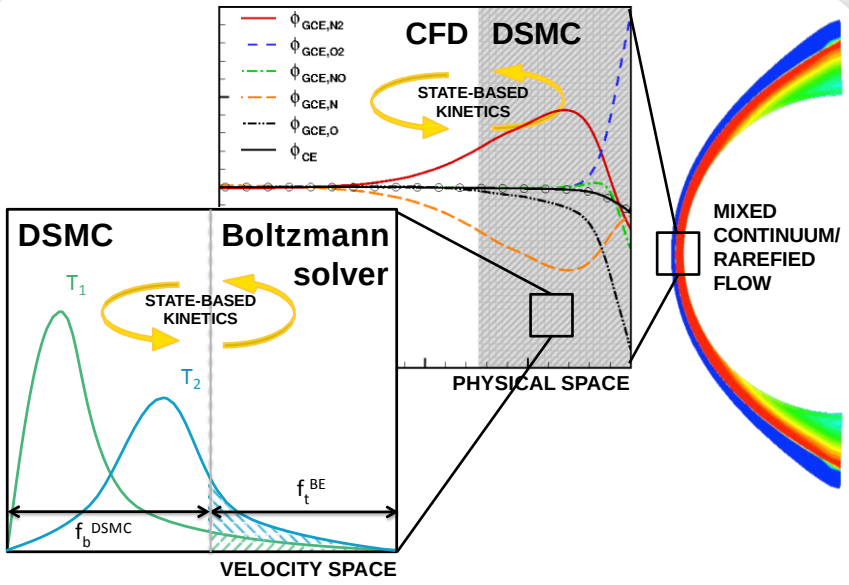
## Research Objectives

Develop framework for combined continuum/rarefied flows through the following thrust areas:

***State-based kinetics*** – address long-standing inconsistencies in CFD/DSMC thermochemistry models through state-based kinetics

***Assessment of continuum breakdown in high-speed reacting flows*** – establish (i) new set of breakdown parameters for reacting flows, (ii) mechanisms leading to continuum breakdown in reacting flows, and (ii) flux-based hybrid interface from GCE Theory

***DSMC/BKE coupling*** – resolve high energy tail-driven processes in DSMC




**CFD/DSMC coupled in physical space** for continuum/rarefied regions (top). **DSMC/ Boltzmann velocity space coupling** provides statistically smooth kinetic correction for 'tail-driven' processes in high-energy DSMC distribution tail (bottom).

## Approach

- **CFD/DSMC coupling**: continuum breakdown parameters/mechanisms, hybrid interface location (*physical space*)
- **DSMC/BKE coupling**: improve poor statistics in DSMC high-energy tail with deterministic Boltzmann solver (*velocity space*)
- Develop reduced order state-based kinetics model with consistent CFD/DSMC energy binning

## Potential Impact

*This ECF Award will enable reduced-order state-based hybrid methods to support NASA aerothermodynamics modeling and TPS/mission design efforts*

- Reduce uncertainty in predictive capability of localized non-continuum effects/transitional flows
- Tighter margins on TPS/aerodynamic design
- Embraces new paradigm of consistent state-based kinetic descriptions for direct infusion to NASA codes