Air-Carbon Boundary Layer Chemistry for Hypersonic Ablation

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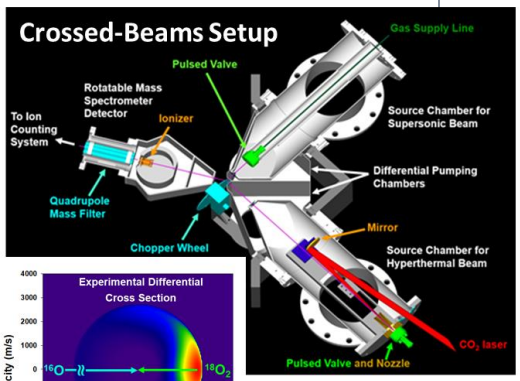
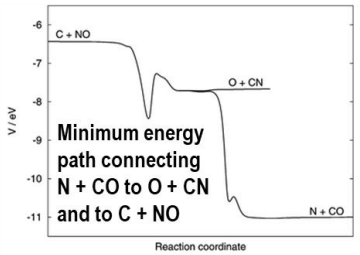
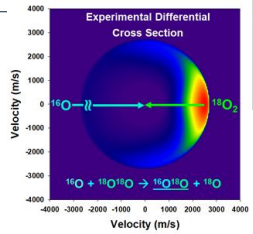
Research Objectives

- Formulate air-CO/CO_2 reaction rate models, grounded by fundamental data, for use in CFD that can in turn be validated through comparison with ongoing high-enthalpy ablation experiments and shock-tube experiments.
- Innovative chemistry-focused approach to target key boundary layer reactions individually.
- SOA: Validate gas-surface reaction models with measurements taken within the boundary layer… how to validate the accuracy of gas-surface models if boundary layer chemistry is uncertain?
- Move scientific knowledge and methodology from TRL1 to TRL2, and promote a transformation in boundary layer modeling from TRL1 to TRL 3.

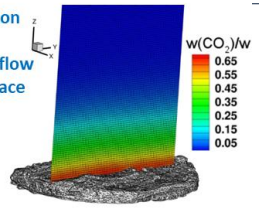






Differential cross section for the O + O_2 exchange reaction derived from a crossed molecular beams scattering experiment.

CO_2 mass fraction from DSMC simulations of flow over a TPS surface



Research Objectives

- Crossed molecular beams experiments provide differential cross sections for important ablation reactions, which serve as benchmarks for theory.
- Validated theoretical calculations provide detailed dynamical information, as well as trustworthy rate data.
- Hypersonic flow simulations with sensitivity analysis identify the key reaction processes.
- New data obtained from fundamental experiment/theory studies are incorporated into DSMC simulations, and final validation studies demonstrating agreement with molecular beam data, computational chemistry results, and shock-tube measurements are performed.

Potential Impact

- Accurate information added to database of air-CO/CO_2 chemistry that can be used for boundary-layer model validation studies.
- New reaction mechanisms and rate coefficients incorporated into generic CFD codes, such as the DPLR and US3D codes.
- New models will give more accurate predictions of the chemical state of the boundary layer, which will in turn improve predictions of radiative emission and absorption for hypersonic entry flows.