Advanced Physical Models and Numerical Algorithms to Enable High-Fidelity Aerothermo-dynamic Simulations of Planetary Entry Vehicles on Emerging Distributed Heterogeneous Computing Architectures

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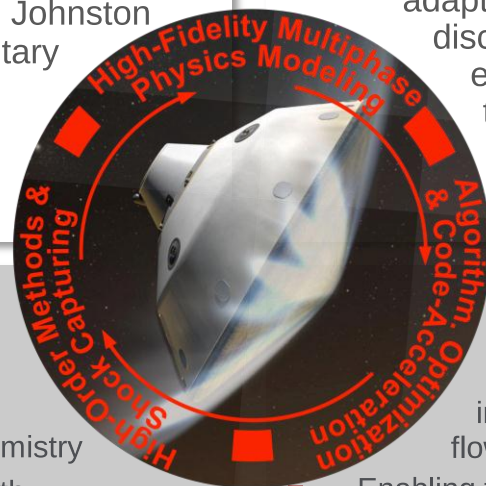
- Interactions with
  - NASA Langley: Drs. Gnoffo and Johnston (code coupling and complementary calculations)
  - NASA Ames: Drs. Barnhardt and Muppidi (model analysis and code comparison)

Research Objectives

- Establish innovative physical models and advanced numerical methods for the reliable prediction of aerothermodynamic flows
  - Develop a high-fidelity model for particle-laden reacting flows to enable the accurate prediction of heat-flux augmentation and vehicle impact in dusty environments
  - Develop advanced shock-capturing and adaptation techniques for high-order discontinuous Galerkin (DG) methods to enable accurate predictions of heat transfer, shocks, and aerothermo-dynamic flows on unstructured and non-conformal meshes



Approach

Effort #1: Develop Lagrangian particle method for multiphase reacting flows, under consideration of coupling between shocks, radiation, pyrolysis, and non-equilibrium chemistry

Effort #2: Develop high-order DG-method with *hp*-adaptation and shock-capturing using entropy-principle; validate and assess accuracy of high-order DG-method for reliable heat-flux predictions on unstructured meshes in aerothermodynamic environments

Effort #3: Evaluate domain-specific programming paradigms for accelerating high-fidelity simulations on emerging heterogeneous and memory-complex computing architectures

All research efforts will be performed using our existing high-order multicomponent reacting DG-method

Potential Impact

High-fidelity physical models and high-order numerical methods can significantly improve predictions of aerothermodynamic flows in support of NASA's future needs by:

- Enabling to assess the impact of multiphase flows on entry-vehicle performance through advanced modeling capabilities for particle-laden reacting flows
- Providing substantially faster convergence and accuracy on unstructured meshes using high-order methods with robust shock-capturing and solution adaptation
- Achieving substantial performance gains of high-fidelity multiphysics simulations through code-acceleration on modern heterogeneous and memory-complex compute architectures

Credit: NASA/JPL