Simulations of Reactive Flows in Supersonic Combustion Chambers

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The mission of the Predictive Science Academic Alliance Program (PSAAP) Center at Stanford is to build and demonstrate computational capabilities for the simulations of combustion engines (scramjet) for hypersonic air-breathing vehicles. The emphasis of the Center is to evaluate the operability limit of a scramjet as the fuel flow rate is increased. Thermal choking, flow separation and flame blow-off are phenomena that can lead to dramatic loss of performance; simulations are critical to achieve safe operation without over-conservative design.

The Center is developing multiphysics computational tools that solve the time-dependent compressible, reacting flow equations on unstructured grids and massively parallel computers. The simulations are carried out with a strict control of numerical errors (using adjoints) and explicit assessment of the uncertainties. These are due to the variability in the environment, e.g. the flight Mach number, to empirical parameters required by the physical models and to potential accuracies related to the turbulence and combustion models employed. The seminar will first focus on the determination of the operating conditions using Bayesian inference and a Pade/Legendre approximation scheme. Afterward, the evaluation of the uncertainties induced by imprecise reaction rate measurements and the use of a low rank representation method will be discussed.