Some Current Issues in the Modeling and Simulation of Hypersonic Flows with Chemistry

See AIAA 2007-0204 by Wadhams et al. and 18 Nov 11 email

1. Shock-tunnel experiments on the Shuttle at 5MJ/kg (Mach-10 flight enthalpy) yield good agreement with computation for both N2 and air, even for separation upstream of body flap.
2. However, at 10MJ/kg (Mach 14 flight enthalpy), body-flap separation and reattachment heating don't agree for N2 and air. CFD can agree for N2 but not air. The air dissociates in the stagnation region of the shock tunnel, generating NO, N, O, and e-; these freeze in the nozzle expansion and change the gas properties. It seems that the NO reactions cannot yet be modeled well.
3. The same problem shows up in the expansions on the aft portion of the Shuttle, on the boattail. N2 agrees well with CFD, but air at high enthalpy cannot be modeled well with CFD or with the shock tunnel.
4. These experiments were run at very low Reynolds numbers so the separated regions were fully laminar, to simplify and ease the comparisons with CFD.
5. CUBRC continues to develop the LENS-XX expansion tunnel to avoid the contaminated freestream chemistry associated with high-enthalpy stagnation regions.