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Author: Dr. Heather Kline
National Institute of Aerospace (NIA), United States, heather.kline@nianet.org

Dr. Chau-Lyan Chang
National Aeronautics and Space Administration (NASA)/Langley Research Center, United States, chau-lyan.chang@nasa.gov
Dr. Fei Li
National Aeronautics and Space Administration (NASA), United States, fei.li@nasa.gov

BOUNDARY LAYER STABILITY AND LAMINAR-TURBULENT TRANSITION ANALYSIS WITH THERMOCHEMICAL NONEQUILIBRIUM APPLIED TO MARTIAN ATMOSPHERIC ENTRY

Abstract

As Martian atmospheric entry vehicles increase in size to accommodate larger payloads, transitional flow should be taken into account in the design of the heat shield. The mass of the Thermal Protection System (TPS) comprises a significant portion of the vehicle mass, and a reduction of this mass would result in fuel savings. The current techniques used to design entry shields assume fully turbulent flow when the vehicle is large enough to expect transitional flow, and while this worst-case scenario provides a greater factor of safety it may also result in over-designed TPS and unnecessarily high vehicle mass. Greater accuracy in the prediction of transition would also reduce uncertainty in the thermal and aerodynamic loads. The Parabolized Stability Equation (PSE) method offers a physics-based method of transition prediction that has been thoroughly studied and applied in perfect gas flows, and to a more limited extent in reacting and nonequilibrium flows. PSE, and other e^N-based methods such as Linear Stability Theory (LST), predict the growth of a known disturbance frequency and amplitude and/or the growth the the most unstable mode. Transition is predicted to occur at a critical amplification or N Factor, frequently determined through experiment and empirical correlation. The LAngley Stability and TRansition Analysis Code (LASTRAC), with modifications for thermochemically reacting flows and arbitrary gas mixtures, will be presented with PSE results on a simulation relevant to Martian entry shielding, and using a multispecies gas mixture approximating Martian atmospheric compostion. The current capabilities of LASTRAC and further developments required for practical application to transition prediction for TPS design will be discussed.