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Stability Analysis of a Mach 10 Boundary Layer with Nonequilibrium Chemistry SHIRIN GHAFFARI, OLAF MARXEN, GIANLUCA IACCARINO, ERIC SHAQFEH, Stanford University, THIERRY MAGIN, von Karman Institute — High temperature conditions in high Mach number flights can invalidate the assumption of a calorically perfect gas. As temperature rises, thermodynamic and transport properties of the gas mixture become not only a function of temperature but also of the chemical composition. If chemical nonequilibrium exists, additional transport equations for the species densities should be solved. Chemical nonequilibrium in the bulk can strongly affect boundary layer stability and transition to turbulence and thus it is an important capability to have in direct numerical simulation of high Mach number flows. At present, not many high-order numerical methods are capable of handling the high temperature regime. We examine boundary layer stability of a Mach 10 flow over a flat plate for the bulk in chemical nonequilibrium but thermal equilibrium. We carry out a high-order numerical integration of the Navier-Stokes equations via direct coupling to a library that computes gas properties based on the kinetic theory. Spatial amplification of small disturbances that may lead to transition on an isothermal or adiabatic flat plate are investigated.

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