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Modeling the stochastic dynamics of moving turbulent spots over a slender cone at Mach 5 during laminar-turbulent transition[1]

BRIAN ROBBINS, RICH FIELD, Sandia National Laboratories, MIRCEA GRIGORIU, Cornell University, RYAN JAMISON, MIKHAIL MESH, KATYA CASPER, LAWRENCE DECHANT, Sandia National Laboratories — During reentry, a hypersonic vehicle undergoes a period in which the flow about the vehicle transitions from laminar to turbulent flow. During this transitional phase, the flow is characterized by intermittent formations of localized turbulent behavior. These localized regions of turbulence are born at the onset of transition and grow as they move to the aft end of the flight vehicle. Throughout laminar-turbulent transition, the moving turbulent spots cause pressure fluctuations on the outer surface of the vehicle, which leads to the random vibration of the structure and its internal components. In light of this, it is of great interest to study the dynamical response of a flight vehicle undergoing transitional flow so that aircraft can be better designed to prevent structural failure. In this talk, we present a statistical model that calculates the birth, evolution, and pressure field of turbulent spots over a generic slender cone structure. We then illustrate that the model appropriately quantifies intermittency behavior and pressure loading by comparing the intermittency and root-mean-square pressure fluctuations produced by the model with theory and experiment. Finally, we present results pertaining to the structural response of a housing panel on the slender cone.

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