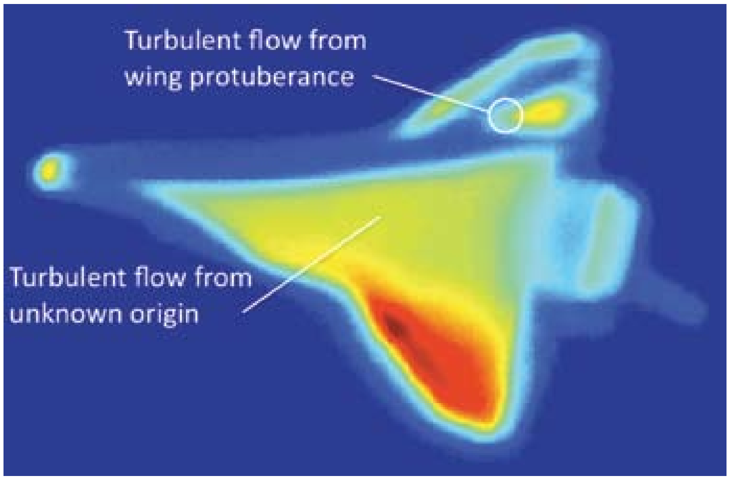
Space Travel

Hypersonic Transition to Turbulence

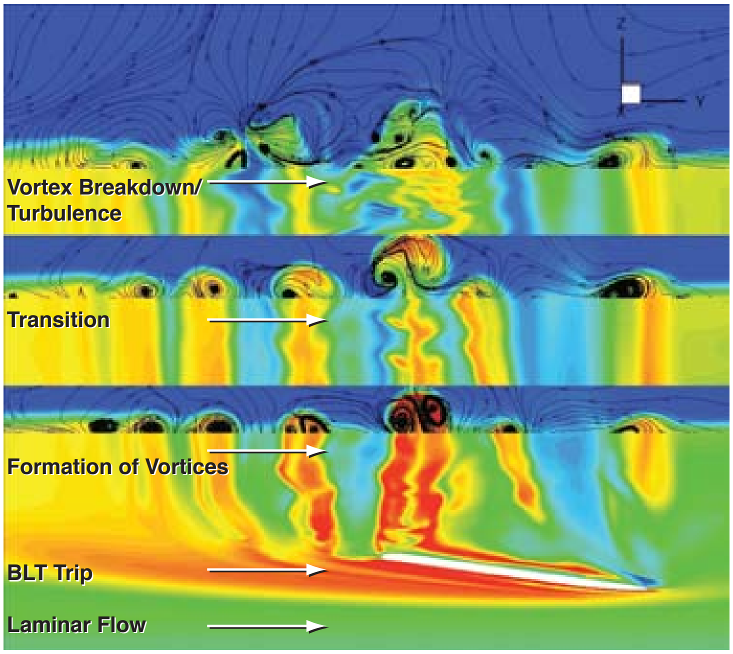
Prediction and control on boundary layer transition in hypersonic flows are crucial to the design and safety of planetary entry vehicles. Since turbulent heat transfer rates can be up to five times higher than laminar heating rates, reduction in the weight of thermal protection systems can be realized with an improved understanding of the physics of transition from laminar to turbulent flow.

The gap-filler incident on the Space Shuttle mission STS-114 in 2005 was a potent reminder of the importance of accurate prediction of roughness-induced boundary layer transition and subsequent increase in surface heating. The robust and accurate prediction of aerodynamic heating is a cornerstone-enabling requirement. The present results show successful prediction of hypersonic transition to turbulence using the high-fidelity Detached Eddy Simulation method.

The massive, fine-grid unsteady computations needed for this work were made possible by NASA's Pleiades supercomputer.



Fine-grid simulation of roughness-induced boundary layer transition to turbulence (circle on image indicates area of turbulent flow from protuberance on wing of the Space Shuttle).



Temperature contours of hypersonic transition to turbulence over the Space Shuttle body: Blue planes (at 30h, 60h, and 85h from the trip) are perpendicular to the horizontal plane (at 0.5h from the wind tunnel wall); h = boundary layer trip height.

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