ABSTRACT

The objective of this Vannevar Bush Faculty Fellowship is to improve basic knowledge of wall–bounded gaseous turbulence when exposed to extreme hypervelocity environments. The studies will provide experimental observations and theoretical foundations for improved understanding and simulation of high-temperature multi-physics problems, which have important science and engineering applications across all branches of the DoD. Of specific interest are (i) the organized vortex structure within the wall-bounded flows, e.g., hairpin vortices and streaks, and (ii) the mechanisms that couple turbulence to molecular energy exchange dynamics and/or chemical reactions. A comprehensive experimental campaign will be performed to provide observations of the flow structure within high-temperature wall-bounded viscous flows. The experiments will take place in a large-scale high-energy hypervelocity research tunnel at Texas A&M University that is capable of extreme thermal environments (11-MJ/kg). Non-intrusive laser diagnostics will be employed for simultaneous planar measurement of velocity and temperature. These data enable documentation of the instantaneous flow structure and statistical moments, including molecular energy exchange. The dynamics of the flow structure will be examined using a 1.0 MHz pulse-burst laser high-speed imaging system. A theoretical effort will be performed to advance a mathematical treatment to include molecular energy exchange processes for LES subgrid closure. This program will provide unique opportunities for students and research scientists at the intersection of advanced hypervelocity experimentation, high fidelity turbulence transport simulation, and *ab initio* molecular simulation inspired thermochemical energy exchange. Strong interactions with the DoD are planned to inform the research team on DoD developments, challenges, and future directions. The PI has a strong track record in this regard, as he routinely maintains an educational partnership agreement with the AFRL. *If successful, this study will, for the first time, provide experimental observation of the basic structure of hypervelocity wall-bounded turbulence, which will enable direct validation of theory.*