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**Direct Numerical Simulation of Turbulent Premixed Hydrogen/Air Flames in Sheared Turbulence and in Counterflow with Product Stratification**

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Petascale direct numerical simulations (DNS) have been performed of canonical turbulent configurations to glean physical insight into turbulence-chemistry interactions in combustion and to provide validation data for the development of coarse-grained models for engineering CFD. The role of DNS is illustrated through two examples. In the first example, DNS of turbulent hydrogen/air premixed flames interacting with intense shear driven turbulence in the thin reaction zones regime at turbulent Reynolds numbers approaching 1000 (Hawkes et al. 2012) are performed over a range of Damköhler numbers. The DNS data are used to study inter-scale energy transfer through one-dimensional spectra of turbulent kinetic energy and reactive scalars from the turbulent premixed flames. Balance equations for the density weighted turbulent kinetic energy and scalar fluctuation spectra for reacting flows are derived and used to understand the physical processes unique to reacting flows. In the second example, DNS of highly turbulent lean premixed hydrogen-air flames stabilized against counterflowing non-adiabatic stoichiometric combustion products in chemical equilibrium are performed. The influence of product stratification on the mechanisms associated with local extinction and re-ignition in turbulent stratified combustion is studied.

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