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Advances in Optical Diagnostics for Extreme Aerothermal Flows

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Propulsion, transportation, and energy systems rely on chemical reactions that occur under highly dynamic temperatures, chemical species concentrations, fluid phase, and pressure. Resolving the complex interactions of these flow properties and their effects on efficiency, performance, and harmful emissions requires advanced non-intrusive measurement techniques that can span a wide range of spatial and temporal scales. This talk focuses on recent advances that extend the applicability of laser-based measurements along two main directions: (1) tracking the four-dimensional (*x*-*y*-*z*-*t*) evolution of species, velocity, and temperature in aerothermal flows and (2) quantitative measurements at extreme flow velocities, pressures, and temperatures. Recent developments of burst-mode lasers and high-speed cameras have enabled 4-D measurements of fuel tracers, combustion intermediates (OH, CH2O, PAH), pollutant emissions (soot), temperature, and velocity in turbulent flames [1,2]. This talk will present some of the considerations associated with quantitative measurements under challenging conditions, including interferences from various photophysical effects, optical access, and experimental complexity [5]. The prospects for further development of laser sources for capturing highly dynamic phenomena are also discussed. This includes the development of MHz amplified nanosecond to femtosecond lasers that can enable the use of molecular tagging velocimetry, coherent Raman scattering, and flowfield imaging at unprecedented rates [3,4]. Finally, it is important to consider the prospects for mining the large data sets generated by the aforementioned optical diagnostics to capture the relevant dynamics.

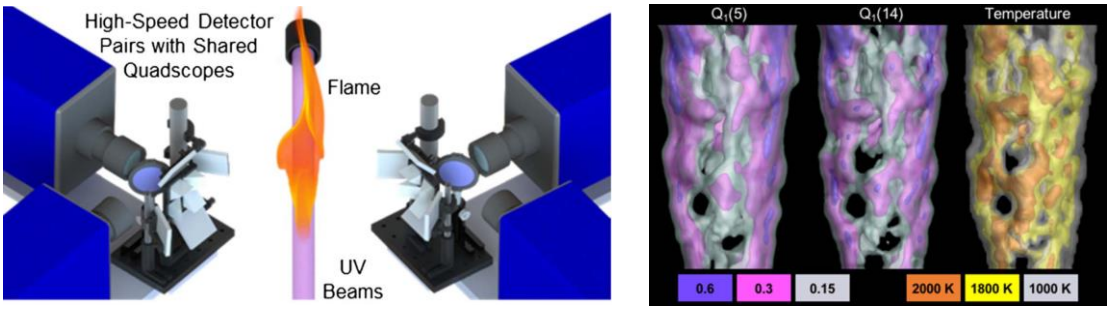

Fig. 1. Optical layout for 3-D imaging of the hydroxyl radical (left) and demonstration for simultaneous species and temperature measurements in turbulent flames (right) [2].

References

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