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Spontaneous Raman temperature mapping of an overexpanded supersonic jet

This work reports in-situ non-invasive temperature measurement performed by spontaneous Raman scattering spectroscopy [1] in a round free-stream supersonic air jet produced by the ADIJe facility (Dlphasic Analysis of Jets) at ONERA. The medium is excited using a continuous monochromatic laser radiation at 532 nm emitted from a high-power fiber laser (10 W) focused using a 150 mm focal length lens. The backward spontaneous Raman scattering is collected using the same lens as the excitation for a robust optical design, and analyzed in a 300-mm focal spectrometer. The well-resolved rotational structure of N₂ and O₂ follow a Boltzmann distribution that is fitted to estimate the internal temperature at the measurement volume.

Hyperspectral data are acquired by scanning the measurement volume across the flow in several planes of interest. Precise temperature maps are retrieved (Figure 1), exhibiting a complex shock structure characteristic of over-expanded supersonic jets, and show good agreement with the flow field simulated by Large Eddy Simulation (LES). Raman temperature measurements has been previously used to investigate supersonic jets [2-4], and probe the temperature field in the vicinity of a Mach disk produced by an overexpanded hot air jet. However, to the best of the authors' knowledge, the temperature map presented in this work is unprecedented in both sampling density and spatial extent, allowing detailed and unambiguous reconstruction of the geometry of multiples shock cells.

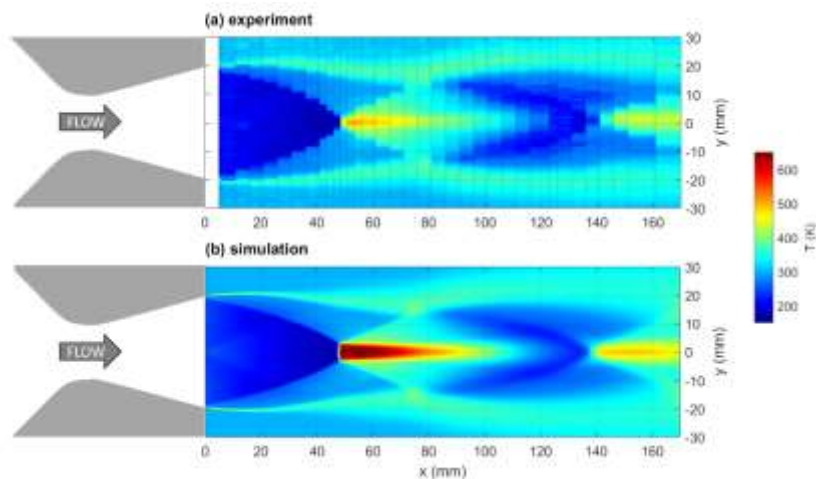


Figure 1: (a) Temperature measurement achieved performing vertical scans (transverse to the flow direction) in the nozzle outlet, and (b) LES simulation.

References

- [1] D. A. Long, Raman Spectroscopy, Cas-Gaw Hill: New York 1977
- [2] G. Tejeda, et al., Physical Review Letters, Vol. 76, No. 1 (1996), 34-37
- [3] M.P. Wernet, et al., Experiments in Fluids, Vol. 62 (2021), 62:61
- [4] B. Wu, et al., Optics Letters, Vol. 50 (20215), 4618-4621