Recent progress in filtered Rayleigh scattering: Towards the simultaneous acquisition of pressure, temperature and three-component velocity fields

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HIGHLIGHTS

- The filtered Rayleigh scattering, extended by the method of frequency scanning (FSM-FRS) has the capability to simultaneously acquire time-averaged pressure, temperature and velocity maps.
- Laser-induced background scattering as well as an erroneous modelling of the Rayleigh scattering's spectral shape are identified to have detrimental effects on FSM-FRS measurement accuracies.
- In applying a background correction methodology as well as in replacing the standard lineshape model by an empirical formulation, deviations between reference experiments and FSM-FRS results are reduced below 15 hPa, 2.5 K and 2.7 m/s, respectively.
- For the first time in the literature an FRS velocimeter is proposed, which, by observing the plane of interest from three different directions by means of a multiple-branch wound image bundle, is capable to simultaneously acquire time-averaged pressure, temperature as well as three-component velocity fields.

ABSTRACT

The contribution summarizes recent efforts to provide methods to reduce uncertainties of FSM-FRS measurement results as well as to exploit the FSM-FRS methods capabilities to simultaneously provide time-averaged pressure, temperature and three-component velocity fields. Based on a multiple-branch wound image bundle, the plane of interest is observed from multiple directions. The resulting variation of Doppler frequency-shifts for each camera view enables the reconstruction of a three-component velocity vector at each sensor pixel. Hence, FRS offers a viable alternative to existing (seeding based) velocimetry approaches, providing three-component velocity fields as well as temperature and pressure distributions simultaneously.

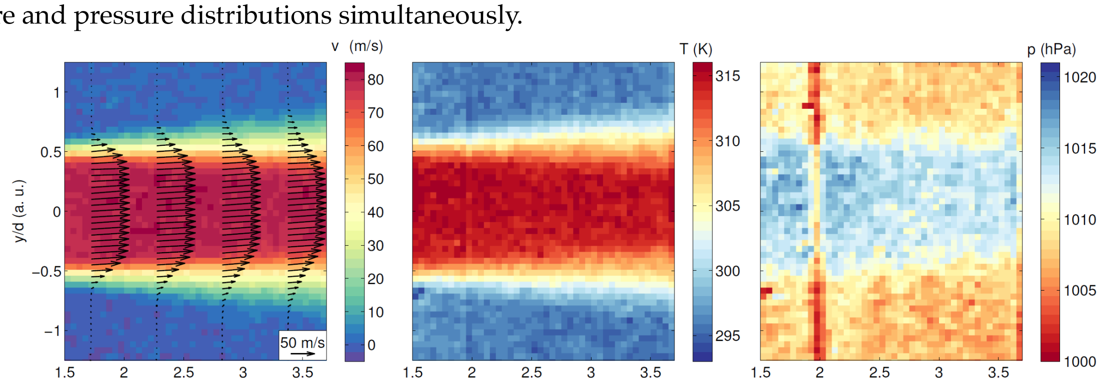

Fig. 1 Measured near-field velocity (left), temperature (middle) and pressure distributions (right) in a heated turbulent jet in air. Axial velocity and temperature show a typical near-field topology, with constant values inside the jet's potential core, strong gradients in the growing shear layer and ambient conditions in the almost undisturbed outer region.