



QUANTITATIVE VISUALIZATION OF INSTANTANEOUS PRESSURE BASED ON 4D-PIV AND FLOW GOVERNING EQUATIONS

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KEYWORDS:

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Fluid: transitional and turbulent regime, aeroacoustics

Visualization method(s): high-speed tomographic particle image velocimetry, 4D-PIV

Other keywords: momentum equation, Lagrangian acceleration, Poisson equation

ABSTRACT: Flow visualization techniques have been utilized for the study of several properties such as velocity, density, chemical species and temperature. The visualization of the flow field pressure by direct optical phenomena is rather challenging because the optical properties of the fluid medium (e.g. index of refraction, scattering cross section) do not correlate directly with pressure. Some techniques like the Pressure Sensitive Paint² have developed such that the surface pressure can be accurately measured in high-speed flows. The problem of determining the pressure fluctuations in a fluid, especially in the low speed regime remains unsolved from the point of view of optical techniques.

With the development of time-resolved PIV and of tomographic particle image velocimetry it has become possible to evaluate the flow field velocity spatio-temporal evolution in three dimensions. “Injecting” the measured flow field kinematics in the Navier-Stokes equation leads to a formulation where the only unknown remains the pressure gradient¹. This leads to a novel approach to measure the instantaneous spatio-temporal pressure fluctuations in water and air flows with unprecedented sensitivity to the tiniest fluctuations.

This study presents the most recent developments and applications of this experimental method. The measurement principle is elucidated along with the requirements for its application in incompressible flows. The work includes applications of PIV-based pressure visualization to a rod-airfoil interaction and a developed turbulent boundary layer.

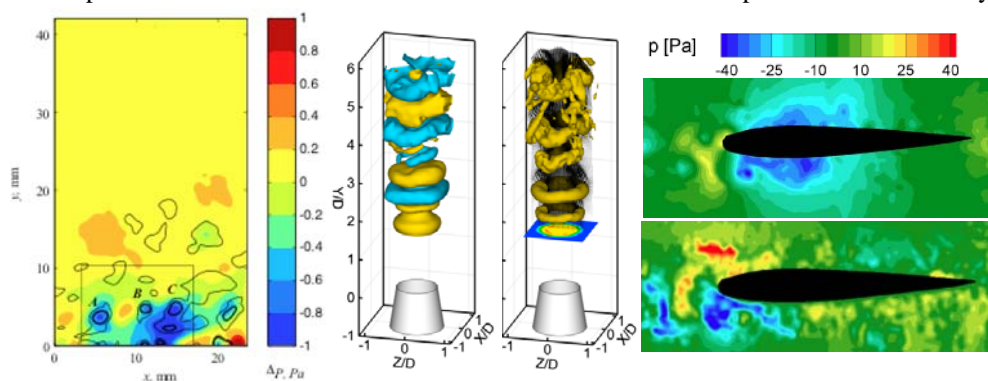


Fig. 1 Instantaneous pressure visualization in a turbulent boundary layer (left), transitional jet (centre-left) and around an airfoil in the wake of a circular rod³ (right). The centre-right figure is a vortex visualization by Q-criterion. The right-bottom figure is the instantaneous vertical velocity field.

References

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