

Flow Visualization and Particle Image Velocimetry of Highly Underexpanded Supersonic Free Jets

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Supersonic free jets play an important role in applied fluid mechanics. The practical applications range from gas flame welding nozzles to propulsion and control nozzles for aeronautical and space applications. In this study a highly underexpanded free jet issuing from a high pressure reservoir through a thin round orifice (10 mm in diameter) into a low pressure chamber was generated by a shock tube (Fig. 1). The pressure ratio stagnation/background pressure was 230 and the test gas was nitrogen. The jet structure was first visualized with a differential interferometer (Fig. 2), which is sensitive to density gradients. The velocity distribution was measured by Particle Image Velocimetry (Figs. 1 and 3). The motivation of this study was that the Mach number distribution on the jet axis of the core flow is well known from experimental and theoretical studies and that the flow gradient produced by the Mach disk can be calculated using the normal shock relations. For these reasons, the highly underexpanded supersonic free jet is particularly attractive as a test flow field for advanced flow diagnostic tools. It can be seen from the figures that the visualized jet structure is well represented by the PIV measurement. The quantitative velocity distribution on the jet axis and across the shock is in good agreement with theoretical values.

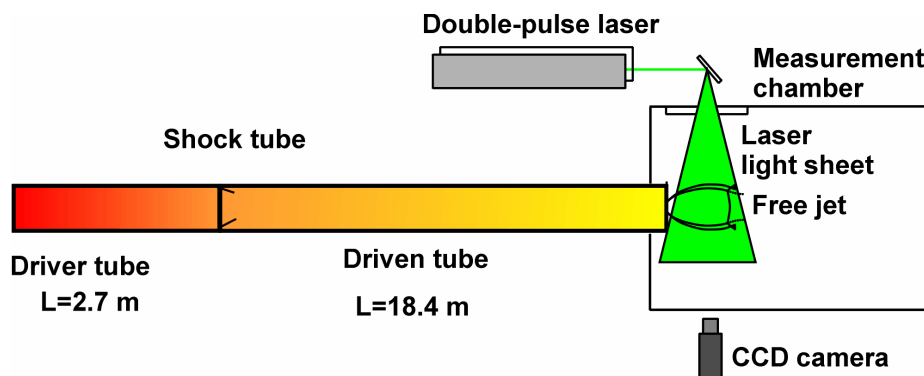


Fig. 1: Shock tube facility with measurement chamber and PIV setup.

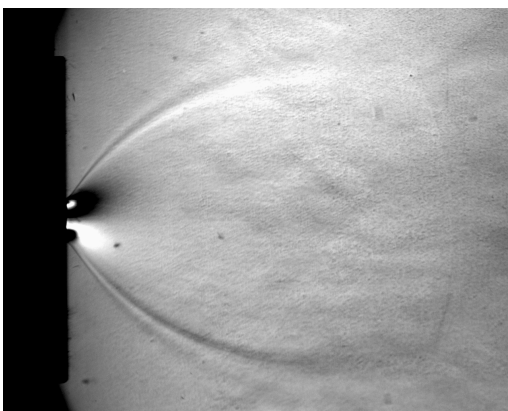


Fig. 2: Highly underexpanded supersonic free jet (pressure ratio: 230). Flow visualization with differential interferometry

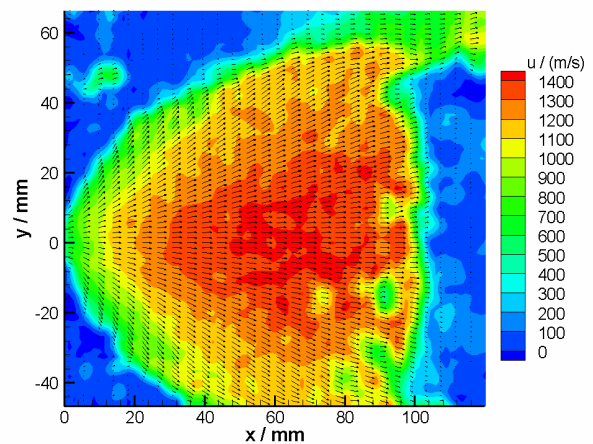


Fig. 3: PIV-measurement result of the free jet