Paper 15.2

Density Field Measurement by Digital Laser Speckle Photography

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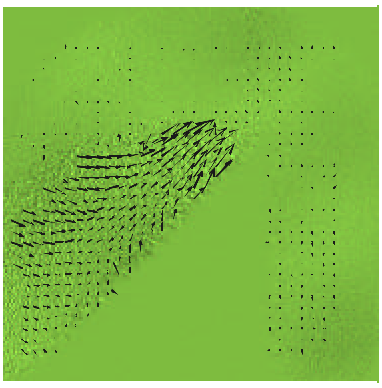
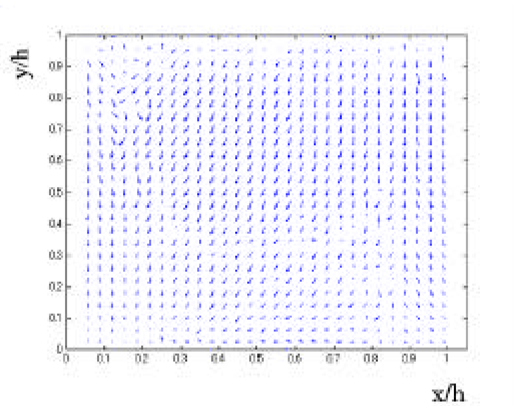
ABSTRACT

Laser speckle photography is a well-established optical method which can be applied to quantitative measurements of density fields of fluid flows in wide dynamic range. In conventional technique of the method, density gradient vector map of a density field is reconstructed by optical Fourier transformation of a double-exposed laser speckle pattern recorded on a photographic film. This analogue method is extended to efficient digital method based on cross-correlation processing of separated images of the reference and the test. The digital technique, called digital laser speckle photography, improves laser speckle photography in the spatial resolution, in the dynamic range and in the efficiency of density field reconstruction. Practical setup of the method is very simple. Since only the light deflection is important for the density measurement in laser speckle photography, it is not required a long coherent light length for the laser source and then it has an advantage rather than the other optical method. The dynamic range and the accuracy of measurement are variable by a simple optical arrangement regulation. Both speckle patterns with and without a phase object placed at the test section are recorded by using a digital still camera or a CCD camera. The digital images of laser speckle pattern are acquired by PC, and the same algorithm with cross-correlation PIV can be applied to obtained the local density gradient vector. In this investigation, the method is applied to density field analyses in two different cases. The first case is density field analysis of Mach reflection of shock wave as a typical problem of compressible fluid flow, and the second is a thermal convection regulated by coupling with an acoustic standing wave induced in a horizontal closed duct. The results obtained are shown in fig.1.



(a) density gradient vector map of Mach reflection



(b) density gradient vector map of thermal convection current

Fig.1 Results of density gradient vector map by digital laser speckle photography.