Visualization of Iso-Gradient Lines in Convective and Diffusive Systems using Gradient-Sensing Interferometry

S.L. Wong, D. Mishra, J.P. Longtin, R. Singh and V. Prasad
Department of Mechanical Engineering
State University of New York at Stony Brook, Stony Brook, NY, 11794

Three-dimensional flow visualization using optical techniques remains one of the most challenging obstacles in understanding and interpreting complex fluid-thermal flows. Over the years, many diverse techniques have been developed for this purpose, including a broad class of interferometric techniques. Most interferometers for convective flow visualizations use a dual-beam configuration that is very delicate, e.g., the Mach-Zhender interferometer. These instruments are extremely sensitive to vibrations and require high-quality optics, while their sensitivity is limited by the wavelength of the light source. In this study, an alternative interferometric technique, the coherent gradient sensing interferometer (CGSI) is employed for flow visualization. This interferometer senses gradients in the refractive index field and eliminates the need for a separate reference beam to create the interference pattern. It is insensitive to vibrations, has no reference beam, and does not require high-quality optics for accurate measurements. The sensitivity of the interferometer can also be easily varied.

The CGSI technique uses two diffraction gratings to create primary and secondary diffraction patterns. These diffracted rays then interfere to create interference patterns. Using a filtering lens, different diffraction-order spots can be separated. First order spots are lines of constant gradient in the refractive index field scanned by the beam prior to its interaction with the first of the two gratings. Gradients perpendicular to the grating directions are visible as fringes. The sensitivity of the interferometer can be easily adjusted by varying the distance between the gratings. Also by changing the grating directions, gradients in any direction can be visualized.

Funding for this work was provided by NSF through Grant No. CTS-0079494