

Overview: Careful and continuous detection of velocity and changes in temperature over a distributed region is required in quite a few contexts. Using appropriate light sources, it is now possible to map velocity and temperature fields over a cross-section and as a function of time. If the region of interest is transparent, beam bending effects can be used to extract information about temperature. Similar principles can be used to determine concentration of salts dissolved in liquids. If the fluid is seeded with particles, velocity information can be extracted. The fundamentals involved in such measurements, experimental setups, data analysis, and a few applications constitute the scope of the website.

About the course: Non-intrusive techniques are extensively used in engineering measurements. These employ radiation sources as probes. All radiation-based measurements share a common feature in that they generate images of a cross-section of the physical domain. This is to be contrasted with mechanical probes which are concerned with measurements at a point in space and can accomplish this task only after the field to be studied has been physically perturbed. Radiation methods are also inertia-free. Hence, by scanning a cross-section of the physical region using radiation probes, a large volume of information can be obtained with practically no time delay. The website has focus on using visible light as a form of radiation for imaging velocity, temperature and species concentration distributions.

Laser-based optical techniques have reached a high degree of maturity. Optical methods, for example, laser Doppler velocimetry and particle image velocimetry have replaced traditional methods such as pitot tubes and hot-wire anemometry. Flow visualization methods of the past have evolved to a point where it is now possible to gain qualitative as well as quantitative understanding of the flow and transport phenomena. Measurement techniques such as Rayleigh and Mie scattering for temperature and concentration measurements and Raman spectroscopy for detection of chemical species in reacting flows are often employed in engineering research.

Whole-field laser measurements of flow and heat transfer in fluids can be carried out with a variety of configurations: shadowgraph, schlieren, interferometry, LDV, and PIV, to name a few. The ability to record optical images in a computer using CCD cameras has greatly simplified image analysis. It is possible to perform operations

such as integration, convolution, and correlations by manipulating numbers representing the image.

Optical measurements can be extended to map three dimensional thermal and concentration fields. An analytical technique called tomography is useful in this context. Here optical images – from interferometry, schlieren or shadowgraph, are viewed as projection data of the thermal field. The three dimensional field is then reconstructed by suitable algorithms.

Course material

Module 1: Introduction, experimental set-up, errors, data acquisition

Module 2: Uncertainty analysis, data analysis, design of experiments

Module 3: Velocity measurement – Laser Doppler velocimetry, particle image velocimetry

Module 4: Principles and applications of interferometry, interference, fringe analysis, tomography, applications

Module 5: Schlieren and shadowgraph, application to crystal growth

Module 6: Liquid crystal thermography, principles, calibration, measurement of heat transfer coefficient

Module 7: Scattering techniques - Rayleigh, fluorescence, Raman