Paper 2.3

Tunnelling Velocimetry: consilience comes to the study of fluid dynamics

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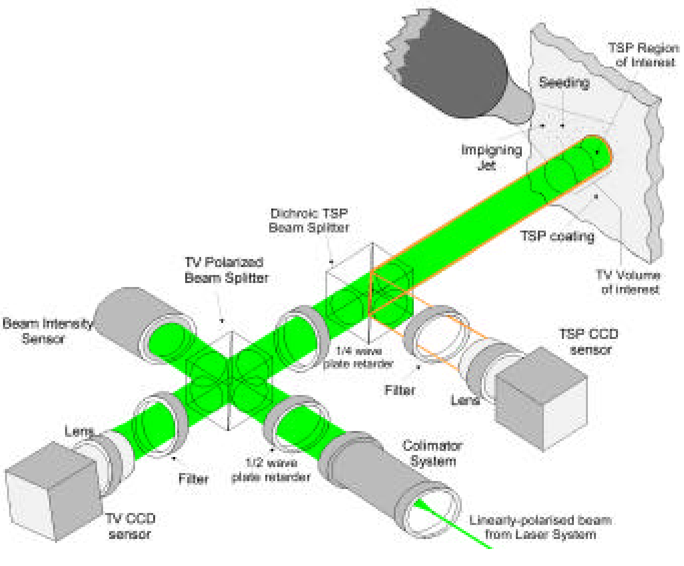
ABSTRACT

It has indeed been clear for some time that in the field of fluid dynamics there is a need to bring a "jumping together" of knowledge, by linking facts and theory across disciplines to create a common groundwork of explanation[1]. In order to describe the realities of unsteady flow, it is necessary to make three-dimensional, non-intrusive, instantaneous and simultaneous flow measurements of the four fluid variables: temperature, density, pressure, and velocity, sometimes together with body surface pressure/temperature distributions. A new technique has been developed which brings together much of the recent knowledge gained in optical metrology, diffraction theory, luminescence barometry, thin films, and data analysis. A single instrument has been developed, capable of making real-time 3D fluid velocity and near-surface temperature/pressure optical measurements non-intrusively, simultaneously and instantaneously, using a single optical access point. Moreover, the method can potentially be extended to make fluid temperature, density and pressure measurements. A prototype velocimeter is shown schematically in Figure 1. A flow streams along a profile. The flow is seeded with particles, such as polystyrene spheres. A collimated laser beam – typically vertically polarised - introduced into the optical axis of a video detector by a polarised beam-splitter illuminates the flow field. A quarter-wave retarding plate is placed between the polarising beam-splitter and the volume of interest to circularise the polarisation of the illuminating beam on its way to the measurement volume, and also serves to make the particle-scattered light horizontally-polarised on the return path. Thus, the polarising beam-splitter transmits the scattered mostly horizontally polarised light onto the imaging lens and CCD camera. Hence the name of the technique: it is as if the camera was viewing the particles, from whose motion velocity is derived, inside a lit tunnel. The laser is pulsed and the CCD camera records multiple images of the light scattered back by the seeding particles. These concepts are at an early state of application and much work remains to be done but there is a myriad of application areas. Tunnelling velocimetry is being successfully developed to enable the four-variable investigation of fluids and their interactions with surfaces. This technique opens the way for the investigation of complex flow phenomena with high accuracy, using a robust and cost-effective means of measurement.

Figure 1 - Tunnelling Velocimetry (TV) system.



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