Editorial

H. J. Caulfield, Editor

Tutorial Materials in Optical Engineering

With this issue we revive a practice once common in Optical Engineering—the inclusion of tutorial material in the SPIE Reports. This offers me a chance to say what I hope these tutorials can accomplish and to seek reader assistance in finding topics and authors for future tutorials.

Optical Engineering is aimed at those people who make optics work. The archival papers are intended to share specific information on what the authors have achieved in very specific areas. The SPIE Reports are intended to provide other forms of usable information. One of the practical problems faced by every optical engineer in the world is the fact that he cannot be an expert in all of the areas which bear directly on his project. Some of those areas are covered well in books. This is why I regard our book reviews as vital. Other areas are not covered in books because they are too new, the audience is too low, or the amount of material is too limited. For these areas, the tutorial is the ideal vehicle for communication.

The tutorial author must combine acknowledged authority with a skill for communication. Clearly this is a very difficult task. Accordingly, I am delighted that the first tutorial under my editorship is by the authoritative and productive team of George O. Reynolds and John B. DeVelis writing on a subject with which they have been concerned for the last fifteen years—coherence effects in instrument design.

Theirs will be a tough act to follow but it needs to be followed. Many tutorial topics occur to me but the motivation must come from you. Please share with me your thoughts and suggestions. Optical Engineering will be your journal to the extent that you participate in it.
1. INTRODUCTION

Recent reports and publications have indicated renewed interest in applying laser velocimeter (LV) systems, to the measurement of three simultaneous components of velocity. It is of interest, therefore, to briefly describe the technology in this area which has been reported thus far in the literature or which is presently known to the author. It should be pointed out that all three component laser Doppler velocimeter (LDV) systems reported thus far are of the measurement of nonorthogonal velocity components. These components are then transformed into an orthogonal set by transformation equations of the Euler type. 1

The examples of three component laser velocimeter systems which have been reported thus far in the literature can be divided into either (1) local oscillator systems wherein reference beams are used, or (2) combination local oscillator and differential Doppler systems, or (3) angularly separated differential Doppler systems. These systems are briefly discussed in the following sections.

1.1. Local oscillator systems

The most notable systems of this kind reported thus far or which have been proposed have been those by Huffaker; 1 Jackson, Polakoff, and Harwell; 2 and by Rizzo. 3 The system reported by Jackson et al. is identical to the system originally described by Huffaker. 1 Figure 1 illustrates the optical arrangement which is used in such a system. Basically, a single laser beam is focused into the flow and transmitted into the detector assembly. Scattered light from three different directions which are symmetrically located about the primary beam is folded into the reference beam thereby providing three nonorthogonal velocity components. This system was mounted on a large mill bed and used a very sturdy optical system to maintain alignment. However, it provided considerable data as evidenced by the report by Jackson et al. 2

The system described by Rizzo is apparently not nearly as sensitive to angular alignment with the reference beams since it used a scattering plate arrangement to provide a broad spectrum of potential reference directions for the scattered beam. 3 It also measures nonorthogonal velocity components.

1.2. Combination local oscillator and differential Doppler systems

These systems have been described by Farmer, Hornekohl, and Brayton; 4 Orloff and Logan; 5 and Schwieos, Cupp, Post, and Calfee. 6 The system described by Farmer et al. was operated over a transmission distance of approximately 30 meters and was originally intended as a system to be operated in atmospheric applications. However, it was not found sufficiently sensitive for ranges much greater than 30 m because of atmospheric scintillation and the need for relatively high data rates which it was unable to provide. It was found, however, that in short term applications, it did work reasonably well, although spatial resolution in the third component which used a local oscillator beam was poor. It should be pointed out that in this type of approach the angles between the measured velocity components were all nearly orthogonal. Two such components are directly orthogonal and the third is not perpendicular to the other two by less than a degree. The system described by Orloff and Logan was capable of directional sensitivity via a Bragg cell frequency shifter and used polarization separation to identify the respective components. Again, it provided two orthogonal velocity components and a third component which was nearly orthogonal to the first two. The system described by Schwieosow et al. was originally designed to measure velocities in atmospheric vortices, such as dust devils, and to be of a sufficient size that it could be flown in a small airplane. It utilized a combination, which to this author’s knowledge has not been proposed before, wherein two reference beams were made to cross and focus at point S (see Fig. 2). The local oscillator beams produced two nonorthogonal components. A third component which was perpendicular to the bisector of these two beams was determined through the interference generated between beams 1 and 2. Spatial resolution for this system was found to be quite poor because of the size of the optics and range over which the system operated.

1.3 Differential Doppler systems

These systems have found prominent use in recent applications. Farmer originally described the transformation equations which were required for applying these types of systems to the measurement of three orthogonal velocity components. 7 Since that time, Heitslsey, Crossway, and Brayton 8 have described such a system which has operated on a 1 ft. transonic tunnel at Arnold Engineering Development Center (AEDC) and Yanta 9 described a system which has been operated on a tunnel at the Naval Surface Weapons Center in Silver Springs, MD. Hallermier 10 also described a system which was to be used in the characterization of slow speed gravity waves introduced into the flow. Work by Heitslsey et al. 7 and by Yanta which has brought to the fore some of the major limitations which have been found in trying to use these instruments in the characterization of turbulent flows. Some of these limitations will be discussed in future reports. Here it is of interest to examine most of the major operational limitations which use of these instruments has revealed.

1.4. Major three component LV system limitations

A major concern in applying any of these systems is in the identification and separation of the velocity components. This has been done either through multiple colors, for example, in the use of two or more wavelengths in an argon laser or by frequency shifting by Bragg cells. Polarization separation has also been attempted. However, experience has shown that this approach can often lead to ambiguities.

LV systems which combine differential Doppler and local oscillator types of measurements have conflicting number density requirements. It is generally accepted that differential Doppler systems work best when the average number of particles present in the probe volume is less than one, whereas local oscillator systems work best when there are numerous particles in the sample volume. It is easy to see that striking a happy medium in this case is not easy.

When multiple sample volumes are present, as might be encountered with two angularly separated differential Doppler systems, it has been found that making the sample volumes coincide can be a difficult mechanical problem. This is especially true when large angles are to be used to separate the two beams. This problem is also encountered in two-component multiple-wavelength systems. Even in this case (when a single transmitting lens is used), the angle between the beams forming the probe volume is large, or if a chromatic aberration exists, there can be probe volume misalignment. Obviously, if the probe volumes are not coincident then it will be very difficult to obtain simultaneous measurements of the type required for the computation and subsequent transformation of three orthogonal velocity components. It should also be evident that when it is necessary to make two optical systems form a common focus that optical system alignment and vibration sensitivity become significant and much attention must be paid to mechanical design.

Spatial resolution may vary well be different for any one of the velocity components which are measured. For example, if local oscillator and differential Doppler measurements of the type described by Farmer et al. or by Logan et al. 3 are obtained, then the local oscillator may have a volume which is significantly larger (or even smaller depending on beam size) than that defined by the differential Doppler system. Acceptable error in the velocity measurements

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Fig. 1. Schematic of the three-dimensional local oscillator LDV and its alignment relative to the exhaust plume flows.

Fig. 2. Three-dimensional LDV by Schwieosow et al.
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has been shown to depend on the separation angles between the two systems as defined, for example, in the paper by Farmer. Recent experience has indicated that the errors for characterizing turbulent flow may be totally unacceptable for all system orientations less than 90° when three velocity components are to be measured.

The problem which has not received a great deal of attention in the laser velocimetry literature is that of trade-offs among the effects of velocity component measurement coincidence. It would be desirable to obtain the three velocity components all from the same particle. This, of course, presumes that all the sample volumes are coincident. Even when they are coincident it may arise that the signal processing electronics will not respond at the same time to the particle generating the signal. Hence, multiple component signal processing systems are often arranged such that they do not have to begin simultaneously to acquire valid data. In other words, it has been generally found that if the electronics are configured for simultaneous signals that data rates become unacceptably low. The errors which are attendant to this type of trade-off have not been studied in detail and will require much additional study. Finally, it should be pointed out that multiple component LDV systems are very data intensive and can require large computer memories. For example, each data point might require, (a) velocity component identification, (b) magnitude, (c) orientation, (d) direction, and (e) relative acquisition time. Additionally, a need may exist to improve these measurements such things as a simultaneity test for when the various components are measured and after the data are obtained to calculate the appropriate coordinate transformations if three nonorthogonal velocity components are, indeed, measured. As might be surmised from the above, the problems encountered as one increases the number of velocity components measured in any given situation is a highly nonlinear function of difficulty. However, it appears we are on the threshold of a new wave of information in this area of laser velocimetry with the development and application of two major system such as have been described by Hetslers et al.8 and by Yanta.9

Sixth European Conference on Optical Communication


Reviewed by Gerald B. Brandt, Manager, Electro-Optics, Westinghouse Electric Corporation, R&D Center, 1310 Beulah Road, Pittsburgh, PA 15235.

In order to qualify for archival status, or at least sufficient status to justify space on a bookshelf already crowded with the fruits of the information explosion, conference proceedings should be timely and representative of the state of the art of the field at the time of the conference. By prompt publication in an attractive format of the 3- to 5-page extended abstracts of the Sixth European Conference on Optical Communication, the Institution of Electrical Engineers has produced a timely summary of international efforts in fiber optics communications systems and the related device technologies. Although the conference was held in England, and in spite of its title, the conference was truly international in scope with the exception that only one paper represented optical communications work from a Communist country. Thirty percent of the papers were contributed by authors with Japanese affiliation, and several other papers included Japanese authors on leave to Europe. This number, compared with the twenty percent each contributed by authors from the United Kingdom and United States, makes clear both the magnitude of the Japanese effort in fiber optics communications and their willingness to talk about their work. For the readers of Optical Engineering, this publication offers a good opportunity to sample the international efforts in optical fiber communications with a timely snapshot of a rapidly moving field.

Optical communication for the purposes of this conference is defined exclusively as optical fiber (fibre in the proceedings) communication systems and the components needed to realize them, namely, fibers, sources, detectors, couplers, and switches. Much of the device work involves research aimed at overcoming shortcomings in existing devices. Much of the work on fibers and systems involves evaluation of the properties and performance, with the goal of making incremental improvements. Integrated optics was represented by only seven percent of the papers, consistent with the pragmatism of the conference and its treatment of operational or nearly operational devices and systems. One key area of the conference dealt with characterization of fiber properties, namely the dispersion, mode, and polarization retention properties of fibers. Characterization studies has remained a constant proportion of the offerings at the conferences since 1975, according to Sandbank in the introductory paper; however, as fiber losses have dropped, integrated optics represented only a small proportion of the papers, as did the session on coupling methods. These sessions represent nascent efforts to put additional signal processing and switching at the ends of the fiber links. Finally, sessions on fiber optic cables and fiber-optic systems completed the conference.

My copy of the conference proceedings is a 5-page extended abstracts of the Sixth European Conference on Optical Communication, the Institution of Electrical Engineers has produced a timely summary of international efforts in fiber optics communications systems and the related device technologies. Although the conference was held in England, and in spite of its title, the conference was truly international in scope with the exception that only one paper represented optical communications work from a Communist country. Thirty percent of the papers were contributed by authors with Japanese affiliation, and several other papers included Japanese authors on leave to Europe. This number, compared with the twenty percent each contributed by authors from the United Kingdom and United States, makes clear both the magnitude of the Japanese effort in fiber optics communications and their willingness to talk about their work. For the readers of Optical Engineering, this publication offers a good opportunity to sample the international efforts in optical fiber communications with a timely snapshot of a rapidly moving field.

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Safety with Lasers and Other Optical Sources


Reviewed by Leon Goldman, Laser Laboratory, University of Cincinnati Medical Center, Cincinnati, OH 45267.

As the authors indicate, it has been almost a decade since there was a detailed review article on the hazards of optical radiation. With the increasing developments of lasers and other optical devices in such diverse areas as industry, military, biology, medicine, and surgery, it is well now to review the hazards. The authors have provided, for all concerned with lasers and optical systems, a very detailed and comprehensive reference handbook for current review. The lasers are covered in detail including brief mention of junction diode lasers. Many hazards are found and not considered. The recent interest and concern of the ANSI-2136 on laser-diode L.E.D. sources with fiber optics has been reviewed, but, as yet, not included in publication. Wolbarsht has been very much interested in the MPE (Maximum Permissible Exposure) and the hazards of lasers and other types of lamps are considered by physicists who usually disregard the establishment. The medical facility is also considered. Here, often the personnel unfortunately learn laser safety from a laser catalogue or the salesman. There is also information for use in industry and military. Lidar applications are also listed in detail. This comprehensive book explores many other sources of lighting systems, fluorescent lamps, mercury pressure, mercury lamps, carbon arc sources, and welding. For these days of health care and warfare there is also a large section on the hazards of the sun and even of daylight. For those who have to give people advice about the commercial sun tanning booths and drugs and materials which make the skin more sensitive to light, this book again provides an excellent background. So, the main concern remains about safety hazards of lasers and other types of lamps are present in this handbook. This will remain the standard bible for evaluating the laser hazards for industry and military. Lidar applications are also listed in detail. There is also a review of x-ray lasers and increasing use of combined laser systems, more information may have to be added in the future. But the basic excellent structure of this book will remain.

Univ. of Wisconsin-Extension programs

The University of Wisconsin-Extension, Engineering and Applied Science, offers the following programs in June: Photogrammetry/#750, June 1-5; Energy Engineering for Buildings-E22777, June 8-12. University of Wisconsin-Extension, Engineering & Applied Science, 432 North Lake St., Madison WI 53706.

Univ. of Michigan infrared courses

Infrared Technology: Fundamentals and System Applications/#8106, June 15-19, 1981. $495. Reflects advances in the state-of-the-art and changes in approaches to utilizing infrared; presentations cover radiation theory, radiative properties of matter, atmospheric propagation, optics, and detectors; system design and the interpretation of target and background signals are stressed. Advanced Infrared Technology/#8107, June 22-26, 1981. $495. Presents the advanced technology need for modern, state-of-the-art infrared and optical systems; presentations cover atmospheric propagation, detectors and focal plane array technology, discrimination characteristics of targets and backgrounds, and system design; prerequisite: familiarity with fundamentals of infrared. Contact fee for 8106 and 8107 is $990. University of Michigan, Continuing Education Engineering, 300 Chrysler Center, North Campus, Ann Arbor M1 48109. 313/764-8490.

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