

BOOK REVIEWS

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LASER-DOPPLER VELOCITY METERS*

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The development of modern science and technology demands the building of improved measuring systems. The further progress of cosmonautics, power engineering, and atomic technology is bound up with a rather complete knowledge of the structure of hydroaerodynamic flows, which can be obtained only by using new methods and means of measurement, since the existing ones do not assure solution of the problems posed.

Present-day requirements in the investigation of flows can be satisfied only by contactless methods, among which optical and laser methods must be distinguished. The use of lasers has permitted us to raise the classical optical methods to a new level and to create new methods. Among the new methods, the most promising has been found to be the Doppler method for measuring the local velocities of flows of liquid and gas, based on measurement of the shift in the frequency of laser radiation, scattered by optical inhomogeneities contained in the flow. At the present time, there can be counted more than a thousand journal articles on the Doppler method; therefore, the appearance of the first monograph on this theme is very timely.

The first chapter of the book is devoted to the principles of the building of laser-Doppler velocity meters. There is a detailed discussion of the Doppler effect and of the basic optical schemes. It is shown that descriptions of optical schemes using the concept of wave-vector space and coordinate space are adequate for the schemes under consideration.

The second chapter is devoted to an analysis of optical schemes by the methods of Fourier optics. This approach is applicable to one of the variants of the work of a velocity meter, in which the diffraction of light on particles is used, i.e., the particles are sufficiently large, and light scattered ahead is used. This method can be used to obtain the dependence of the value of the Doppler signal, of the spatial resolution, and of the accuracy of the measurements on the parameters of the optical scheme. Depending on whether the interference picture is obtained in the measurement volume or in the plane of a photoreceiver, all the schemes can be divided into two groups: with an interferometer at the inlet and one at the outlet.

The third chapter gives optical schemes for the measurement of one, two, and three projections of the vector of the velocity. There is a detailed description of a collective scheme developed by the author, with the suppression of the additive component of the signal, i.e., with subtraction of the envelope. This makes it possible to dispense with further low-frequency filtration, which facilitates processing of the signal in the electronic block.

The fourth chapter gives an analysis of the structure of the Doppler signal, required for the development of the electronic block of the meter. The analysis is made for diffracted light without taking account of coherent effects arising with the simultaneous scattering of the waves on several particles. The theoretical conclusions are well illustrated by a large number of photographs.

The fifth chapter discusses the errors in measurements of the velocity. It is shown that the superposition of signals from two particles leads to a situation in which the instantaneous frequency of the signal can differ considerably from the Doppler frequency. Formulas are given for calculating the accuracy of the measurements of the velocity, without taking account of the noises of the laser and the photoreceiver.

* Izd. Nauka, Novosibirsk (1975), 162 pages.

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The sixth chapter describes systems for the electronic processing of the Doppler signal, on the basis of systems developed by the author's collective. The chapter gives actual variants of schemes with automatic frequency and phase tuning, and gives an analysis of their work.

The seventh chapter gives the results of the application of the velocity meter to the investigation of flows in a hydrodynamic channel and in two-phase gas-saturated aqueous flows.

Unfortunately, the book pays no attention to methodological questions in the use of velocity meters, and the superfluous mathematical treatment of the material sometimes conceals the simple physical picture of the phenomena under discussion.

The book is mainly intended for developers of laser velocity meters; however, it will be useful also to specialists involved in their use, who wish to delve deeply into the possibilities of the method and into the working principles of the instrument, which is designed for progress in the investigational practice of a hydroaerodynamic experiment.