

Author's Preface to English Edition

At present, the laser diagnostics of fluid and gas flows has evolved into a self-sustained area of laser metrology. Methodologically, the laser diagnostics is based on probing of a fluid flow by a laser beam and measuring of transmitted or scattered laser light characteristics. Next, by solving an appropriate inverse problem, one obtains the desired fluid flow parameters. Scientific intuition supported by a profound theoretical knowledge, experimental skill, and a clear understanding of the potentialities of adopted techniques constitute the basis of any physical research. All this holds in full measure for such a scientific area as laser diagnostics.

The purpose of this book is to describe the methods of laser diagnostics of fluid and gas flows that are currently finding wide application in aero- and hydrodynamic studies in various fields of science and technology - power engineering, space and aircraft industry, chemical engineering, metallurgy, biology, environmental science – to name but a few.

In the first part of the book (Chapters 1, 2, 3), the general aspects of physical optics, laser techniques and coherent radiation scattering theory are considered that are essential for understanding of anemometry, interferometry, refractometry, ellipsometry, particle image velocimetry, high-speed filming and other methods used in laser flow diagnostics.

The second part of the book (Chapters 4, 5, 6) is mainly concerned with the Doppler technique of fluid flows local velocities measuring and its use in the analysis of various flow characteristics. Described here are the optical layouts and signal shaping techniques for laser Doppler anemometers and their applica-

tion in fluid flows diagnostics are illustrated by numerous examples.

At present, a vast variety of measuring devices for studying of fluid flows are commercially available, and to make their practical use most effective, one needs a solid professional background to assess the strong and weak points of a particular technique chosen for a particular experimental research. I hope that this book will be suited both for a designer of novel advanced techniques and a user of commercially available instrumentation.

Undoubtedly, this aim has been achieved only in part. Out of the vast wealth of available materials, preference has been given to those topics which, in the author's opinion, may be of particular importance for the reader. At need for more detailed information an interested reader may refer to cited sources.

The English edition of this book differs in many respects from the former Russian version. Actually, all chapters have been revised. Chapter 1 has been supplemented with Section 1.8 in which the principle of CCD camera technique is outlined and its use for optical radiation recording is discussed.

In Chapter 2 major changes have been made in Section 2.2, where the description of laser effect is given in a more concise form. This was done in view of the vast literature that is currently concerned with this topic.

Chapter 3 was supplemented with Section 3.5 where optical methods of particle sizing are described.

Chapter 4 has been substantially extended by adding of three new sections: "Flow Visualisation Using Laser Sheet", "Doppler Global Velocimetry", and "Particle Image Velocimetry".

Also, three sections have been added to Chapter 5. Section 5.7 is concerned with the integral Doppler spectrum for laminar, turbulent and two-phase flows. Section 5.8 is dedicated to an analysis of the Doppler signal frequency measuring conventional techniques over a wide range from a few Hz to a few GHz units. Section 5.9 is focused on computer-assisted methods of Doppler signal processing.

Chapter 6 has been augmented by Section 6.6 where the laser hydrophone principle is described. Bibliography of the English edition has been extended by adding the recently reported books and journal articles.

Before submitting this book to the readers approval, the author deems it his duty to mention the name of V. A. Fabrikant, the author's teacher, co-author, and the editor of the Russian edition of this book. Regrettably, V. A. Fabrikant has not lived to the appearance of the English edition of this monograph.

V. A. Fabrikant was a continuer in the field of research of the famous Russian physicists S. I. Vavilov, G. S. Landsberg and L. I. Mandelstam. His studies into the gas-discharge optics and quantum electronics and his educational practice obtained recognition both in this country and abroad. The contribution of V. A. Fabrikant's works to the emergence of quantum electronics has been vividly demonstrated in the book by M. Bertolotti "Masers and Lasers. A Historical

Approach". Intellectual by birth, he shared the fate of working intelligentsia in the tragically years of the Soviet Russia. Academician A. D. Sakharov, the world-famous scientist and humanist, who maintained friendly with V. A. Fabrikant and who was Fabrikant's coworker over a certain period of time, wrote: "His fate in science was full of dramatism... He proposed the principle of laser and maser effects, ... but the delight of implementing those remarkable ideas – and the fame of it – have become possessions of other people".

In 1951 V. Fabrikant, together with M. Budynskii and F. Butaeva, filed an application for a patent on a new electromagnetic radiation amplification method. It was shown that a medium with population inversion causes an exponential growth in passing radiation intensity. From this application, first a certificate of authorship (1959) and then a discovery diploma (1964) came.

Thus, V. Fabrikant not only suggested the inverse population idea, but he was also able to propose a number of experimental methods for achieving inversion, practically implemented today. Furthermore, he discovered electromagnetic radiation amplification in media with population inversion – a concept which has enabled quantum devices, most notably the laser, to be designed.

Following the advent of the laser in 1960, most of V. Fabrikant's activity focused on gas discharge optics and on developing the physical principles which now underlie the use of lasers in fluid flow diagnostics – an entirely novel and promising application area for the so-called laser Doppler effect. Under his guidance a number of dissertations were written on the subject of flow diagnostics, in which some problems of laser Doppler anemometry have been resolved and which enabled experimental facilities for carrying out research in a wide range of flow velocities (from superflow ones in expanding solids to hypersonic ones in industrial wind tunnels) and flow regimes (laminar, turbulent, and self-glowing) to be developed.

I wish to express my sincere thanks to my colleagues and post-graduate students who have given permission to have some of their results included in the book. Furthermore, this book would have never had the chance to appear without the kind attitude of many co-workers of the V. A. Fabrikant Department of Physics at the Moscow Power Engineering Institute (Technical University). Also, I would like to thank Dr. P. de Groot from the DSM Research (Netherlands) for fruitful and stimulating discussions that contributed much to a higher quality of the book. I highly appreciate the enthusiasm and benevolence of the Publisher, Mr. W. Begel, whose patience and never-failing kindness have made it possible for the book to see the light.

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