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ATOMIC, MOLECULAR & OPTICAL PHYSICS | REVIEW ARTICLE

A review on noise suppression and aberration compensation in holographic particle image velocimetry

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Abstract: Understanding three-dimensional (3D) fluid flow behaviour is undeniably crucial in improving performance and efficiency in a wide range of applications in engineering and medical fields. Holographic particle image velocimetry (HPIV) is a potential tool to probe and characterize complex flow dynamics since it is a truly three-dimensional three-component measurement technique. The technique relies on the coherent light scattered by small seeding particles that are assumed to faithfully follow the flow for subsequent reconstruction of the same the event afterward. However, extraction of useful 3D displacement data from these particle images is usually aggravated by noise and aberration which are inherent within the optical system. Noise and aberration have been considered as major hurdles in HPIV in obtaining accurate particle image identification and its corresponding 3D position. Major contributions to noise include zero-order diffraction, out-of-focus particles, virtual image and emulsion grain scattering. Noise suppression is crucial to ensure that particle image can be distinctly differentiated from background noise while aberration compensation forms particle image with high integrity. This paper reviews a number of HPIV configurations that have been proposed to address these issues, summarizes the key findings and outlines a basis for follow-on research.

ABOUT THE AUTHORS

K F Tamrin received his MEng. (First Class Honours) in Mechanical Engineering from Loughborough University, UK in 2008, followed by research on optical and digital holography at the same institution until 2011. His interests include digital holographic microscopy, laser optical measurement and laser materials processing. He also serves as a reviewer for a number of leading academic journals in laser materials processing.

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PUBLIC INTEREST STATEMENT

Holography is commonly associated with the arts of displaying objects that seemingly appear realistic in three-dimensional space. In engineering and medical fields, holography has been used as a non-invasive tool to (1) record the dynamics of three-dimensional fluid flow phenomena, and (2) replay the same event afterward for further analysis. Nonetheless, the recorded holographic images often appear distorted with poor image quality, making analysis considerably difficult. This article reviews a number of key techniques to address this issue.