Measurement of a laser-induced underwater shock wave by the optical-flow-based background-oriented schlieren technique

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HIGHLIGHTS

• We propose a high-resolution BOS technique based on the optical flow (OF-BOS) for the first time.
• Using OF-BOS technique we calculate pressure field of a laser-induced underwater shock wave, which agrees with pressure measured by a hydrophone.
• In BOS technique, the number density of vectors related to the density gradient strongly affects the accuracy of the pressure field.

ABSTRACT

We propose a high-resolution BOS technique based on the optical flow (OF-BOS) for measuring a laser-induced underwater shock wave such as Fig.1 (a) for the first time. We find that OF-BOS provides a lot of vectors of the local density gradient (1,700 x 1,700 vectors, Fig.1b) than those provided by BOS technique based on PIV (PIV-BOS) commonly used in many researches (212 x 212 vectors). We find that the number density of vectors strongly affects the accuracy of the pressure field. On one hand, in the case of many vectors, we reasonably reconstruct the pressure field, which is similar to Fig.1 (a). On the other hand, in the case of less vectors, it is difficult to reconstruct the pressure field. Furthermore, we compare quantitatively the pressure distribution obtained from OF-BOS, PIV-BOS and a hydrophone (Fig.1c). Remarkably, the pressure distribution obtained from OF-BOS with 3,922 x 3,922 vectors fairly agrees with that obtained with a hydrophone. It indicates that the pressure gradient of the shock front of 21 MPa/mm can be detected with 150 vectors/mm.

![Fig. 1](image)

Fig. 1 (a) A snapshot of shock wave by shadowgraph. (b) The pressure field in x-y surface obtained by PIV-BOS and OF-BOS. (c) Estimation of pressure between PIV-BOS, OF-BOS and a hydrophone.